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CONTENTS

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THE NATIONAL GEOGRAPHIC MAGAZINE

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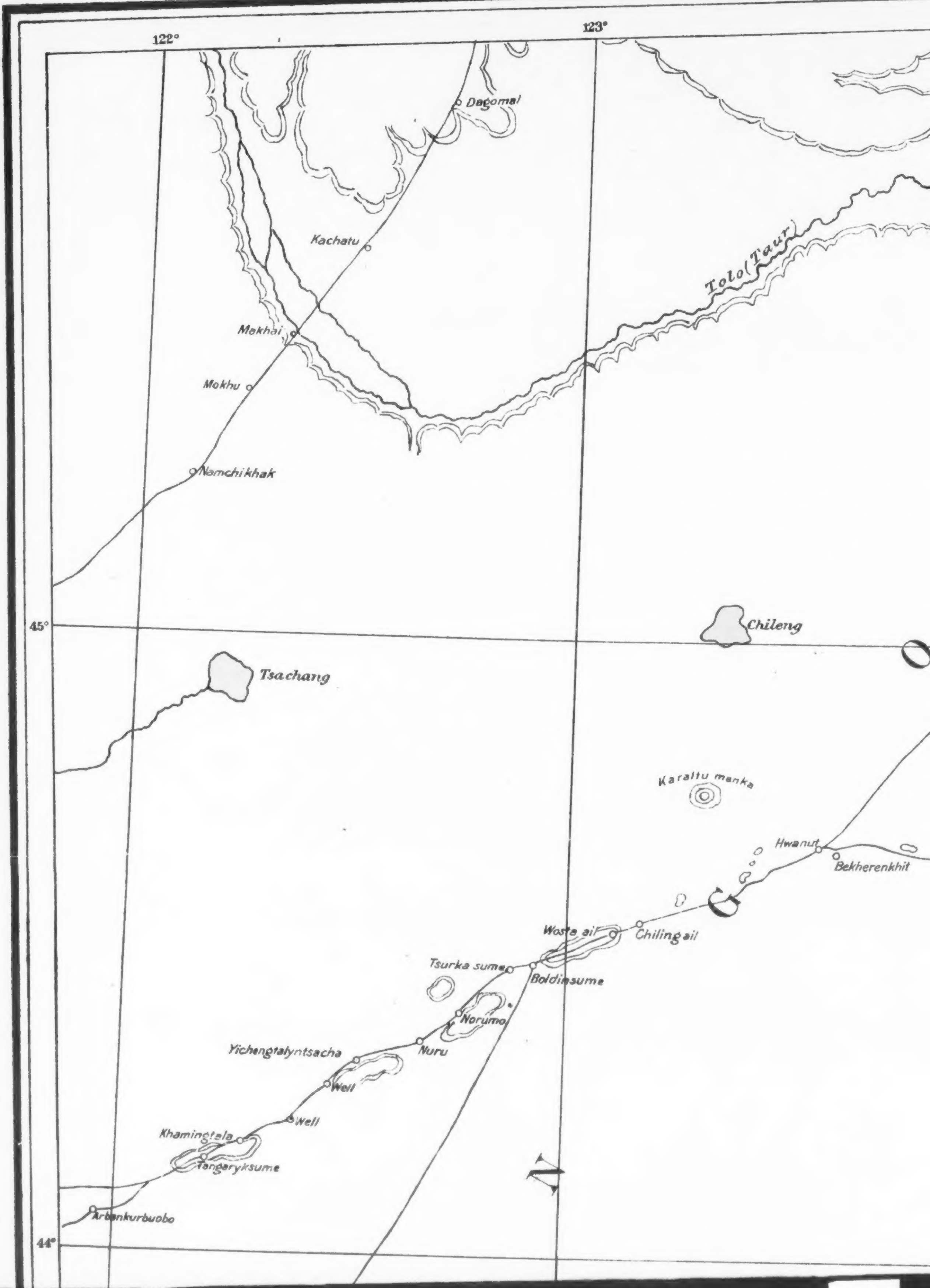
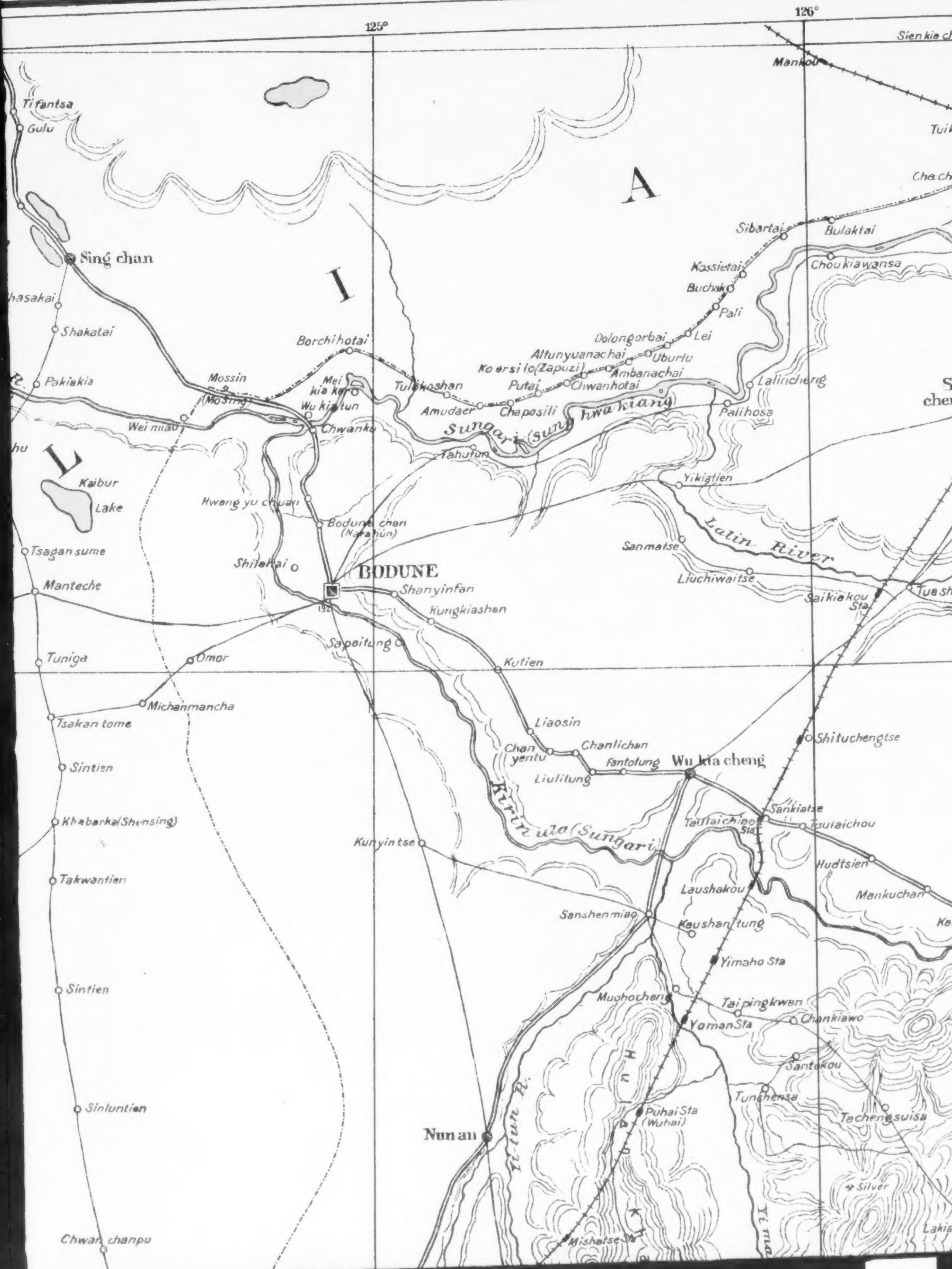
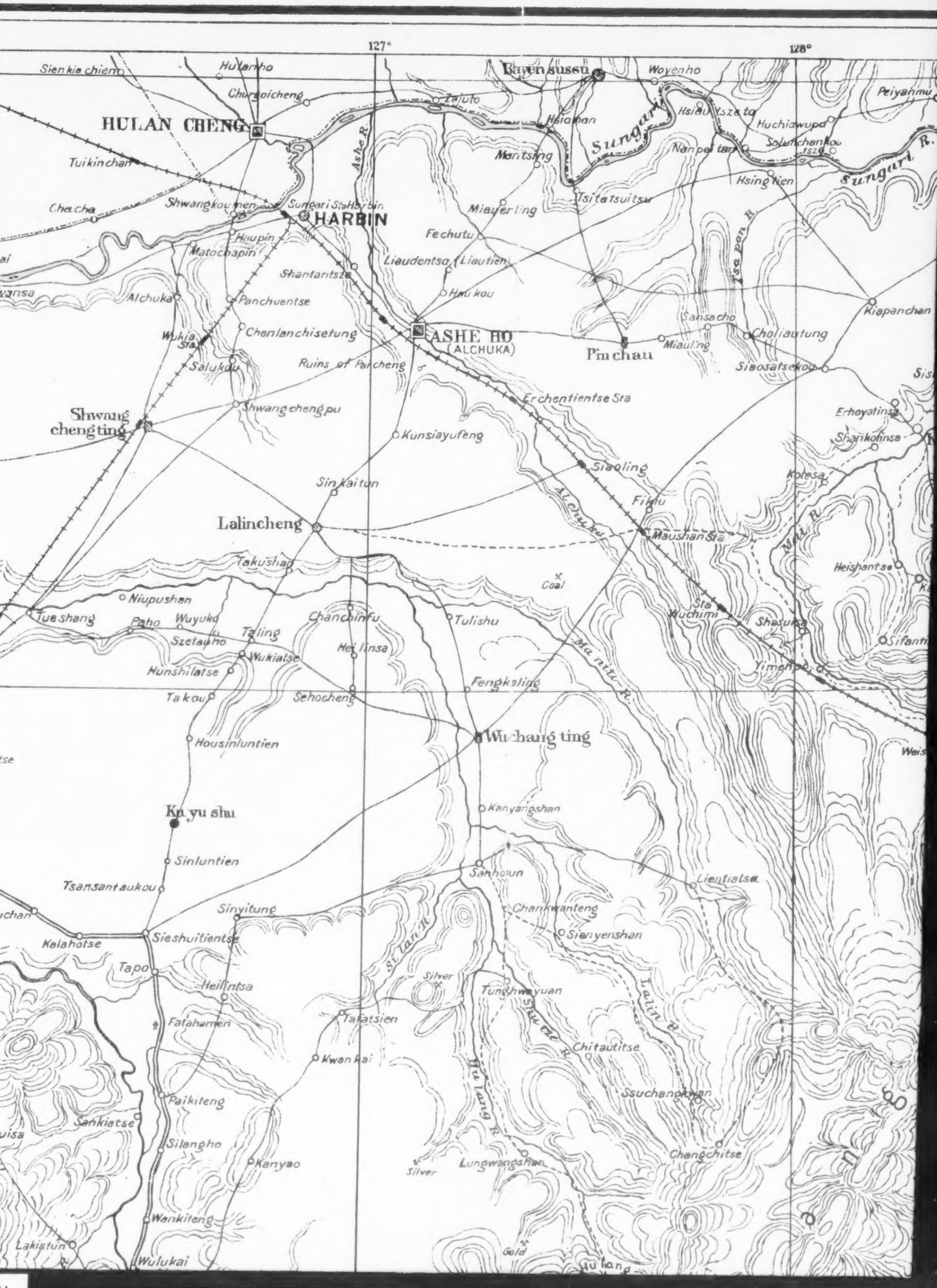

122°
123°
Dagomal
Kachatu
Makhai
Mokhu
Namchikhak
Tolo(Taur)
45°
Chileng
Tsachang
Karaltu manka
Hwanut
Bekherenkhit
Wosta ail
Chiling ail
Tsurka sume
Boldinsume
Norumo
Yichengtalyntsacha
Nuru
Well
Well
Khamingtala
Tangaryksume
Arbenkurbuobo
44°

124°
125°
Nala Jhai
Tifantsa
Gulu
Yuchan
Sai huto
Haupaushi
Sing chan
Shasakai
Shakatai
Yonni R.
Pakiakia
Paushi
A
I
L
O
Borchihotai
Mossin
(MoSing)
Mei
kia kar
Wu kiatun
Wei miao
Chwanku
Tulehoshan
Ko ersi lo (Zapuzi)
Altunyuanachai
Dolongorbai
Uburlu
Ambanachai
Chwanhotai
Putai
Amudaer
Chaposili
Sungari (Sung hwa kiang)
Tahufun
Tahu
Kaibur
Lake
Hwang yu chuan
Bodune chan
(Narahun)
Siliao
Tsagan sume
Shilehai
BODUNE
Manteche
Shanyinfan
Kungkiashan
Sapaitung
Tuniga
Omor
Kutien
Michanmancha
Tsakan tome
Liaosin
Chan
yentu
Chanlichan
Fantolung
Liulitung
Wu kia
Sintien
Khabarka (Shensing)
Kirin ula (Sungari)
Kunyin tse
Takwantien
Yintaiail
Shirka
Sanshenmiao
Sintien
Muohocheng
Sinluntien
Il-tun R.
Puhai Sta
(Wuhai)
Nun an
Chwan chanpu
Mishatse Sta
Sanmatse
Yikia
Liuchi
Kos
Buch
Yoma
Kausha
Lausha
Taitla


125°
126°
Sien kia ch
Mankou
Tuik
Cha che
A
I
L
Tifantsa
Gulu
Sing chan
hasakai
Shakatai
Pakiakia
hu
Kaibur
Lake
Tsagan sume
Manteche
Tuniga
Tsakan tome
Sintien
Khabarka(Shensing)
Takwantien
Sintien
Sinluntien
Chwan chanpu
Sibartai
Bulaktai
Choukiawansa
Kossietai
Buchak
Pali
Lei
Dolongorbai
Uburlu
Altunyuanachai
Ambanachai
Ko ersi lo(Zapuzi)
Chwanhotai
Putai
Borchihotai
Mossin
(Mosing)
Mei
kia kor
Wu kiatun
Chwanku
Wei miao
Tulakoshan
Amudaer
Chaposili
Sungari (Sung hwa kiang)
Tahufun
Lalincheng
Palihosa
Yikiatien
Lalin River
Sanmatse
Liuchiwaitse
Saikiakou
Sta
Tua sh
Hwang yu chuan
Bodune chan
(Narahun)
Shilehai
BODUNE
Shanyinfan
Kungkiashan
Sapaitung
Kutien
Omor
Michanmancha
Liaosin
Chan
yentu
Chanlichan
Fantotung
Liulitung
Wu kia cheng
Shituchengtse
Kirin ula (Sungari)
Sankiatse
Taulaichiao
Sta
Taulaichou
Hudtsien
Mankuchan
Kal
Kunyintse
Laushakou
Sanshenmiao
Kaushantung
Yimaho Sta
Muohocheng
Taipingkwan
YomanSta
Chankiawo
Santokou
Tunghensa
Tachengsuisa
PuhaiSta
(Wuhai)
Nunan
Yi tun R.
Silver
Mishatse Sta
Lakis
SI
chen

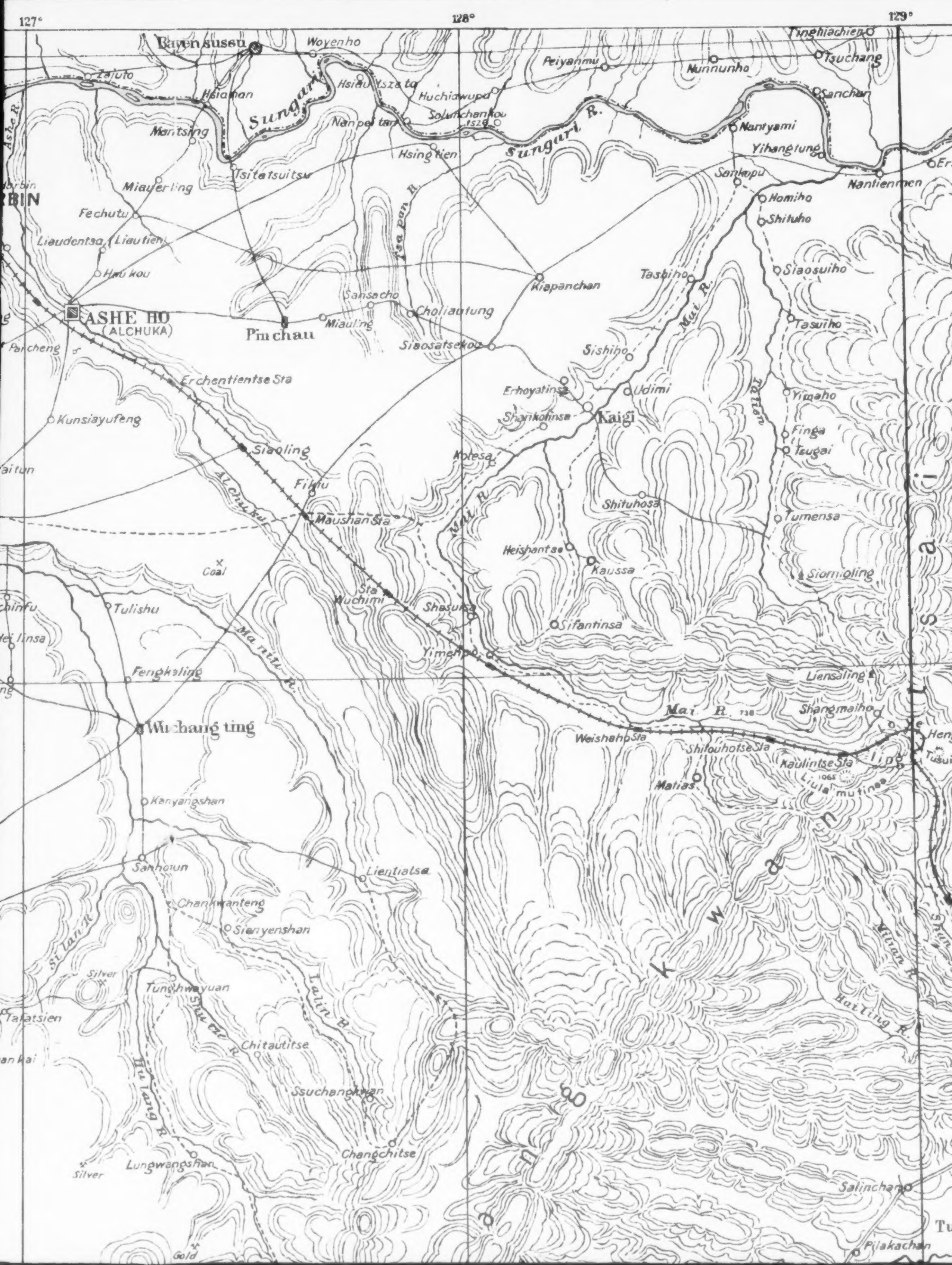
KIR



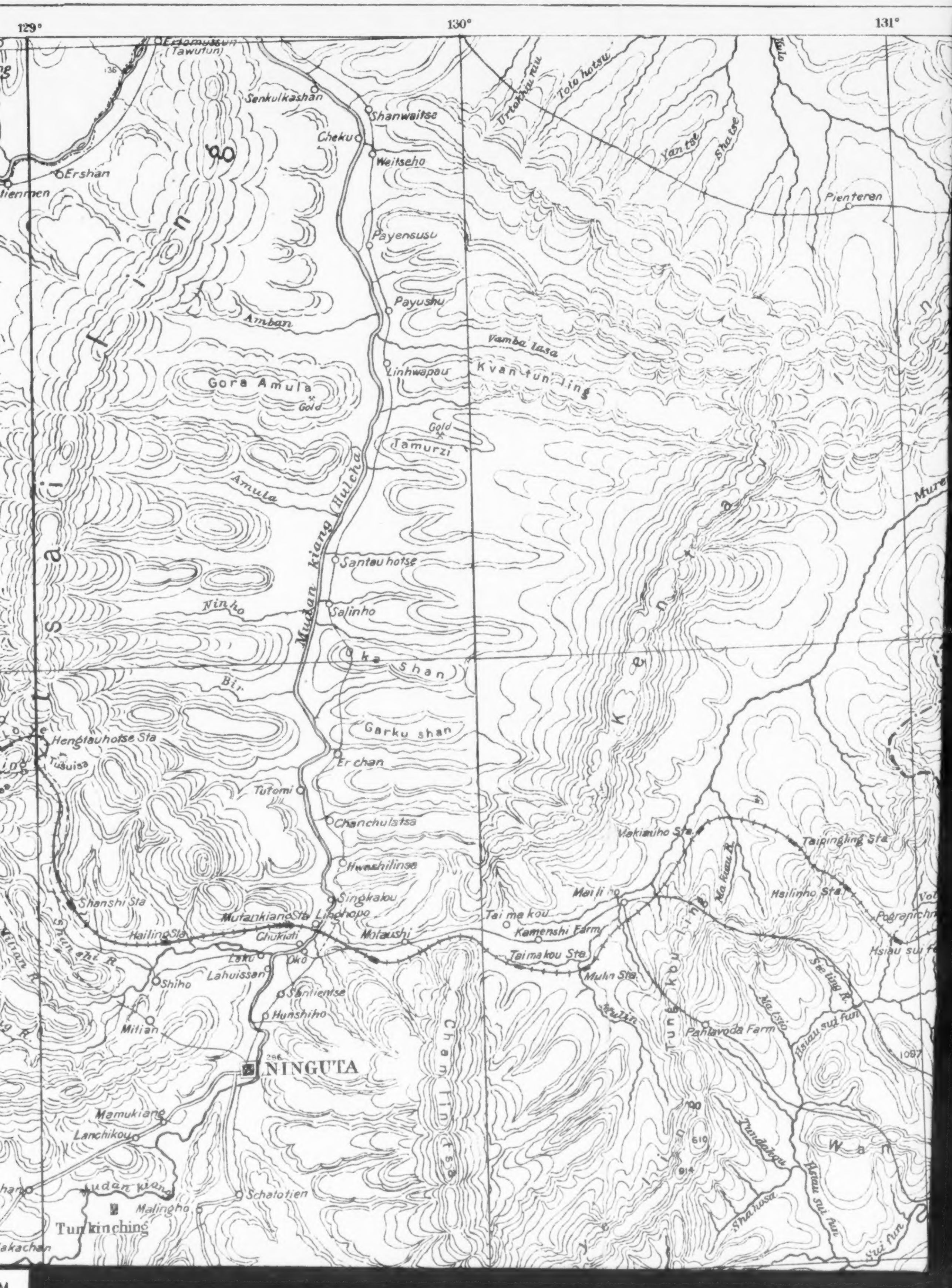
127°
128°
Sien kia chien
Hulanho
Churgoicheng
HULAN CHENG
Bayen sussu
Woyenho
Peiyahmu
Zaluto
Hsiaohan
Hsiau tsze tsu
Huchiawupu
Sungari
Sungari R.
Ashe R.
Mantsing
Nanpei tan
Tuikinchan
Tsitatsuitsu
Hsing tien
Chacha
Shwangkoumen
Sungari Sta Harbin
HARBIN
Miauerling
Haupin
Matochapin
Fechutu
Liaudentsa (Liautien)
Shantantsze
Isapan R.
Alchuka
Panchuentse
Hau kou
Kiapanchan
Sansacho
Chenlanchisetung
Wukia Sta
ASHE HO
(ALCHUKA)
Pinchau
Miauling
Choliautung
Salukou
Ruins of Pancheng
Siaosatsekou
Erchentientse Sta
Shwang chengting
Shwang cheng pu
Erhoyatinsa
Kunsiayufeng
Siaoling
Sin kaitun
Alchuka
Lalincheng
Fiktu
Maushan Sta
Mai R.
Takushan
Coal
Heishantse
Niupushan
Tueshang
Paho
Wuyuko
Taling
Chanchinfu
Tulishu
Sta
Wuchimi
Shasuka
Szetauho
Hei linsa
Wukiatse
Ma niu R.
Sifanti
Hunshilatse
Yimenpo
Takou
Sehocheng
Fengkaling
Wuchang ting
Housinluntien
Kuyu shu
Kanyangshan
Sinluntien
Sanhoiun
Lientiatse
Tsansantaukou
Chankwanteng
Sinyitung
Sieshuitientse
Sienyenshan
Kalahotse
Si lan R.
Tapo
Silver
Heilintsa
Tunghwayuan
Shu ete R.
Lalin R.
Fatahamen
Talatsien
Chitautitse
Kwan kai
Hu lang R.
Ssuchanghwan
Paikiteng
Sankiatse
Silangho
Kanyao
Changchitse
Silver
Lungwangshan
Wankiteng
Lakistun
Gold
Wulukai
Hulang

M

KIRIN, HARBIN, V



N, VLADIVOSTOK.



ADIVOSTOK.


130°
131°
Ertomutsun (Tawutun)
Senkulkashan
Shanweitse
Cheku
Weitseho
Urtohkhu niu
Toto hotsu
Yan tse
Sha tse
Pienteren
Chakula
Lauling
Payensusu
Payushu
Amban
Vamba lasa
Linhwapau
Kvan tun ling
Gora Amula
Gold
Tamurzi
Amula
Muren R.
Mudan kiang (Hulcha)
Santeu hotse
Ninho
Salinho
Oka Shan
Bir
Garku shan
Er chan
Tutomi
Chanchulatsa
Makiauho Sta.
Taipingling Sta.
Hwashilinsa
Singkakou
Maili ho
Hailinho Sta.
Volinka
Mutankiang Sta.
Hailing Sta.
Chukiati
Motaushi
Tai me kou
Kamenshi Farm
Pogranichnaya Sta.
Grotekovo
Laku
Oko
Lahuissan
Shiho
Taimakou Sta.
Muhn Sta.
Hsiau sui feng Sta.
Santientse
Hunshiho
Mitian
Mulin
Pahlavoda Farm
Andreyovka
Sofie
NINGUTA
Chan lin tsa
Tung kou ling
Hsiau sui fun
1087
Mamukiang
Wan lu kou
Udan kiang
Schatotien
Malingho
Shahosa
Sui fun

132°
133°
Chakulan
Faiter R. (Ye er chun)
Tamuren
Seul
Muren R.
Fumishantsu
Malaya Khanku L.
BOUNDARY
LINE
MANCHURIA
SIBERIA
Turirog
Frontier Guard Post
Novo-Kachalanski
Ussatchi
Platono-Alexandrovskaya
Khanka L.
(Hang kai hu)
Longmiau
Post-town No 4
Post-town No 3
Post-town No 2
Pavlo Fedoro
Sungacha
Novo-Mikhailovski
Markovski
Ussuri Sta
Donskoi
Yurte Gadassi
Yurte Bau
Oko Farm
Losingui Fa
Kommissarovskaya
Siyan
Tashu hosa
Ilyinskaya
Lushan
Troitskaya
Levada baravasha
Atamanovskoye
Kamen ribolov
Astrakhenskaya
Novo Selishche
Nun cha R.
Mo R.
Dievitsa
Altinovka
Sandohodsa
Gaivoron
Sinkovka
Suiagina
Dukhovskaya
Alexandrovskoye
Kayevski
Drosdov Sta
Hvatinka
Spasskaya
Yevgenievka Sta
Voskressenka
Bussovka
Prokhorovka
Knorring Sta
Krasni kut
Dmitrovka
Smiachi
Zharikova
Frontier Guard Post Molodetski
Lifuncha Farm
Liesnaya
Mo
Khorolskaya
Popovka
Nesterova
Grotekovo Sta
Boguslavski
Priluki
Merkushevka
Andreyovski
Talovy Sta
Barenonovskaya
Muchnaya Sta
Chernigovka
Gora Pogodina
B
Sofie-Alexieyevski
Nadieshdinski
Chorvatovo Sta
S
Blagodatnaya
Vstriechnaya
Novo-Shastkovo
Liu san kou
Telegraph
Mansovka Sta
Monastirishche
Vosnessenskoye
Novo-Shastkovo
Utesni
Petropavlovka
Lalichi
Dubki
Pavlovka
Gora chornaya
Galenka
Fadieyevskaya
Obrazherevski
Nevelskaya
Konstantinovskaya
Kremovo
Shiriayevka
Orlova
Saboka
Gordiey
Poltavskaya
San cha kou
Strugovka
Ossinovka
Larinskaya
Ivanovka
Kosakevichevo
Varvarovka
Gora
1005
820
714

UM

132°
133°
Faiter R. (Ye er chun)
Tamuren
Seul
Muren R.
Fumishantsu
Malaya Khanka L.
BOUNDARY
LINE
MANCHURIA
SIBERIA
Khanka L.
(Hang kai hu)
Turirog
Frontier Guard Post
Novo-Kachalanski
Ussatchi
Platono-Alexandrovskaya
Longmiau
Post-town No 4
Sungacha
Novo-Mikhailovski
Yurte Gadassian
Yurte Baude
Oko Farm
Losingui Farm
Markovski
Sungacha
Ussuri Sta.
Post-town No 2
Donskoi
Kaul Sta.
Cloister Svienta
Post-town No 3
Pavlo Fedorovski
Shmakovka Sta.
Plantage Komarovka
Kayevski Sta.
Famagu Farm
Suiagina
Dukhovskaya
Alexandrovskoye
Sinkovka
Gaivoron
Sundohodsa
Drosdov Sta.
Hvalinka
Spasskaya
Yevgenievka Sta.
Voskressenka
Prokhorovka
Knorring Sta.
Dmitrovka
Bussorka
Krasni kut
Merkushevka
Chernigovka
Muchnaya Sta.
Gora Pogodinsa
Liu san kou
Telegraph Sta. Yakovleva-Ili
Telegraph Sta. Lasareva
Sissoyevka
Petropavlovka
Mansovka Sta.
Monastirishche
Tashu hosa
Siyan
Kommissarovskaya
Lushan
Ilyinskaya
Troitskaya
Levada baravasha
Atamanovskoye
Kamen ribolov
Astrakhanskaya
Novo Selishche
Mo R.
Dievitsa
Altinovka
Frontier Guard Post Molodetski
Smiachi
Lifuncha Farm
Zharikova
Mo
Liesnaya
Liesnaya
Nesterova
Khorolskaya
Popovka
Boguslavski
Priluki
Talovy Sta.
Baranovskaya
Alexieyevski
Chorvatovo Sta.
Nadieshdinski
S
I
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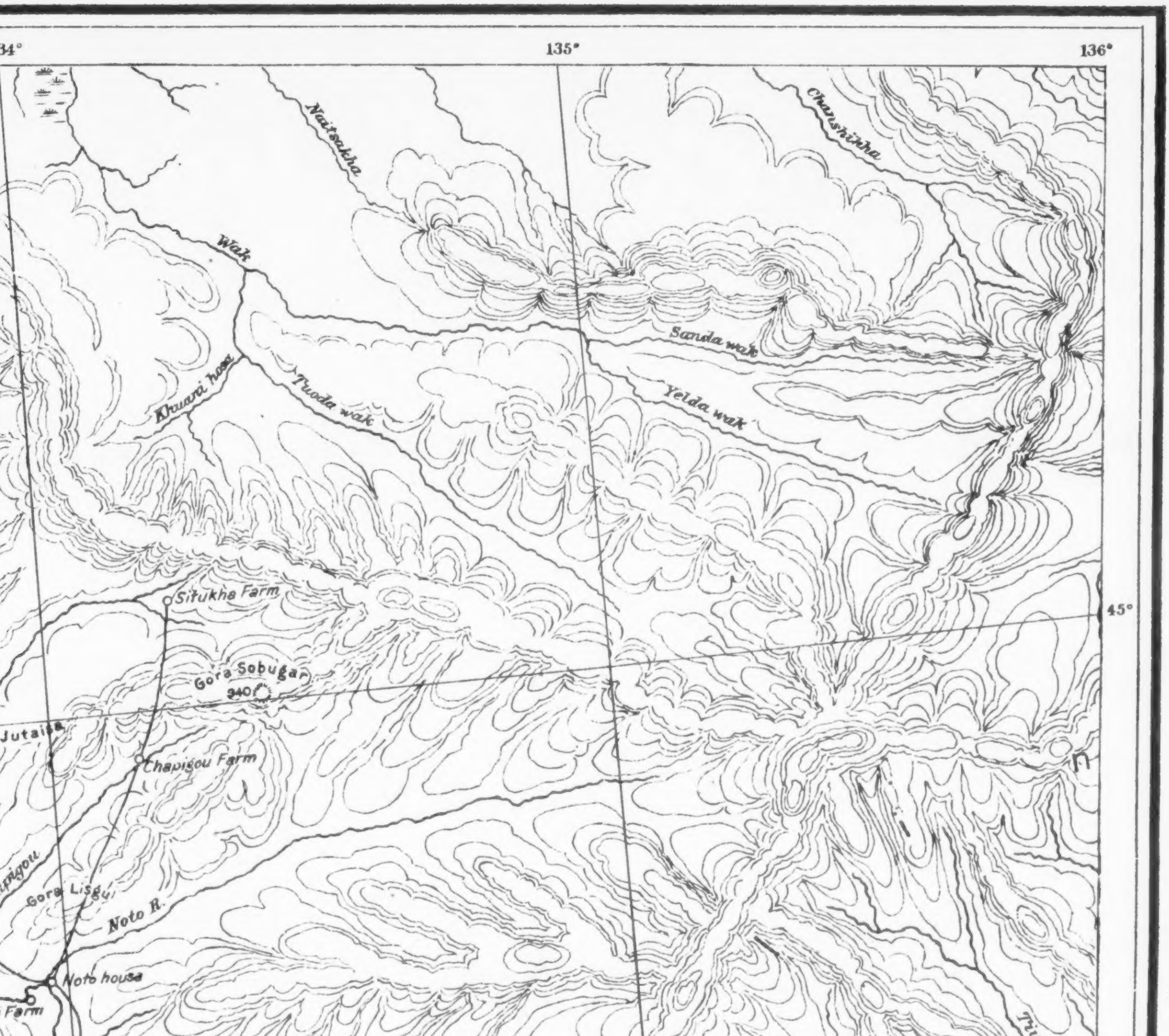
Blagodatnaya
Vstriechnaya
Novo-Shastkovo
Vosnessenskoye
Novo-Shastkovo
Utesni
Dubki
Pavlovka
Galenka
Lalichi
Obrazherevski
Nevelskaya
Gora Chornaya
Fadieyevskaya
Konstantinovskaya
Poltavskaya
San cha kou
Strugovka
Kremovo
Shiriayevka
Orlova
Saboka
Anuchino
Gordiey
Ossinovka
Larinskaya
Ivanovka
Varvarovka
1005
820
714


134°
135°
Iyinski
Verkhni Nikolski
Verkhni Mikhailovski
Panteli Monovskaya
Prohaska Sta.
Busse
Tamga
Medviedıtski
Katarga
Tarashcha
Telegraph Sta.
Tikhmeneva
Cloister
Svienta Troitsa
Uspenka
Nizhne
Romanovskaya
Mali Situ
Bolshoi Situ
Gora Jutaisa
Ussuri
Bieltsova
Famagu Farm
Jumtaisa
Chapigou
Jumtaisa Farm
Wongo
Habitum Farm
Palbo Farm
Situkha Farm
Gora Sobugar
940
898
Chapigou Farm
Gora Lisgu
Noto R.
Noto housa
Lidsungdai
Chingousa Farm
Paugo (Fulisi)
Naitsakha
Wak
Khuani hosa
Tuoda wak
Sanda wak
Yelda wak
Chanshikha
Suanyeseau
Tudogu
Tava hosa
Tudogu
Tiukondogu Farm
Tridogou Farm
Eridogu
Sandogu
Sidogu
Tudogu
1067
Aviabum or Vai n.dsin
Tuga Sandogu Farm
Olgi
Fudin
Sissoyevka
E
R
I

UM

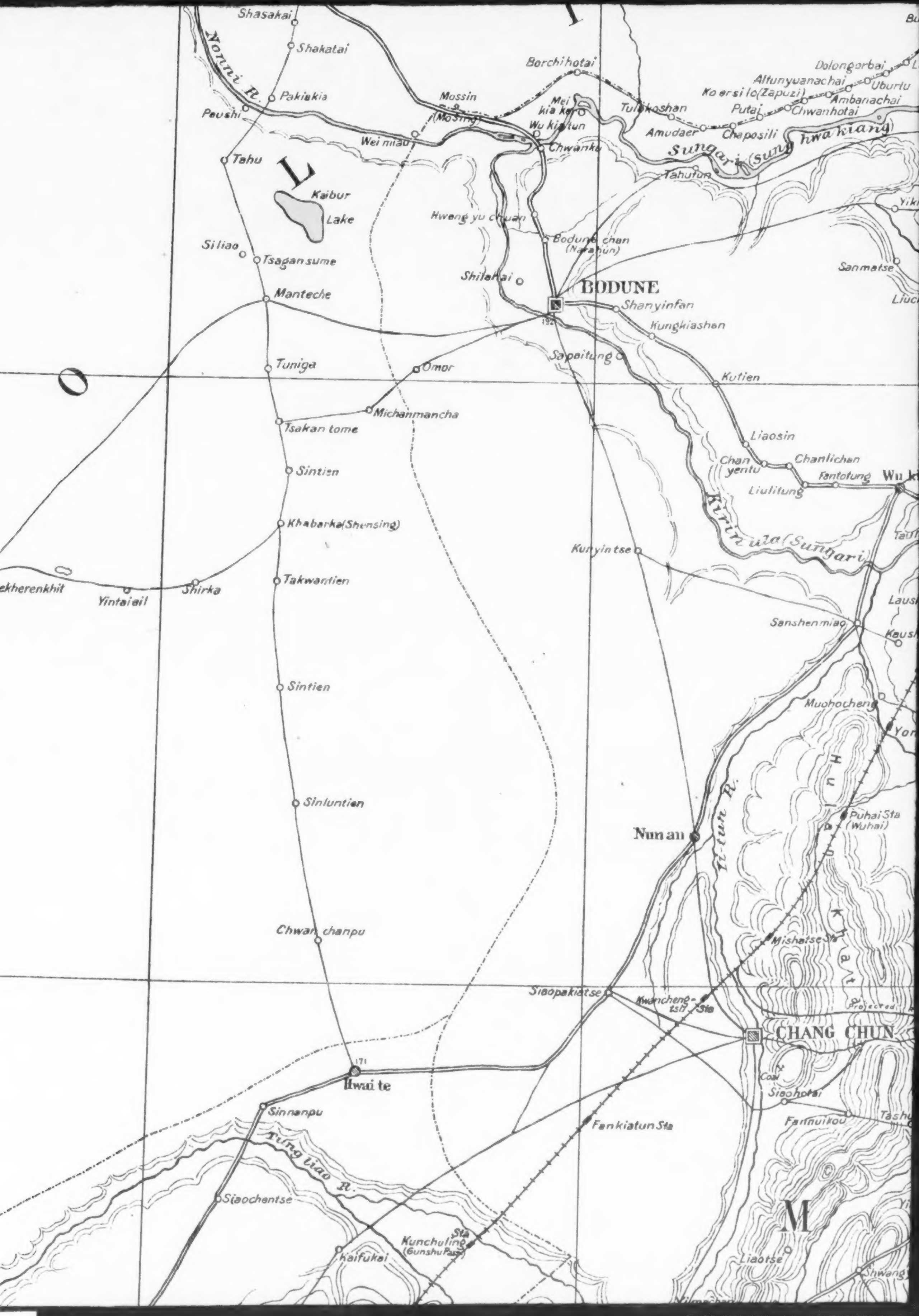

132°
133°
134°
Khanka L.
(Hang kai hu)
Malaya Khanka L.
BOUNDARY
LINE
MANCHURIA
SIBERIA
Muren R.
Tamuren
Seul
Ussatchi
Astrakhanskaya
Mo
Dievitsa
Khorolskaya
Popovka
Blagodatnaya
Vstriechnaya
Utesni
Pavlovka
Kremovo
Ossinovka
Larinskaya
Dubininski Sta.
Kosakevichevo
Ivanovka
Shiriayevka
Orlova
Sebelia
Anuchino
Gordiey
Varvarovka
Gora
Nevelskaya
Obrazherevski
Lalichi
Monastirishche
Vosnessenskoye
Mansovka Sta
Muchnaya Sta
Chernigovka
Liu san kou
Altinovka
Voskressenka
Spasskaya
Prokhorovka
Knorring Sta.
Dmitrovka
Krasni kut
Merkushevka
Gora Pogodina
Gora Chornaya
Petropavlovka
Sissoyevka
Telegraph Sta.
Lasareva
Bussovka
Hvalinka
Drosdov Sta.
Alexandrovskoye
Dukhovskaya
Suiagina
Sinkovka
Gaivoron
Sandokhosa
Novo-Mikhailovski
Longmiau
Post-town Nº 4
Post-town Nº 3
Post-town Nº 2
Pavlo Fedorovski
Shmakovka Sta
Kayevski Sta.
Plantage
Komarovka
Famagu Farm
Bieltsova
Ussuri
Nizhne
Romanovskaya
Uspenka
Cloister
Svienta Troitsa
Telegraph Sta
Tikhmeneva
Kaul Sta.
Donskoi
Ussuri Sta
Medvieditski
Tarashcha
Markovski
Sungacha
Busse
Prohaska Sta
Panteli Monovskaya
Losingui Farm
Oko Farm
Verkhni Mikhailovski
Verkhni Nikolski
Yurte Baude
Yurte Gadassian
Ilyinski
Tamga
Mali Situ
Bolshoi Situ
Gora Jutaisa
898
Jumtaisa
Jumtaise Farm
Hobitum Farm
Changou
Wongo
Palbo Farm
Telegraph Sta
Yakovleva-Ili
Ugodinsa
Suanyeseau
Tudogu
Tava hosa
Sandogu
Eridogu
828
714
1065
I
B
E



34°
135°
136°
45°
44°
Naitsakha
Chanshinha
Wak
Sanda wak
Yelda wak
Khuani hosa
Tuoda wak
Situkhe Farm
Gora Sobugar
940
Jutaisa
Chapigou Farm
Gora Lisgu
Noto R.
Noto housa
Farm
Lidsungdai
Chingousa Farm
Lifudsin
Paugo (Fudsi)
Tridogou Farm
Tiukondogu Farm
Suanyeseau
Tudogu
Tudogu
Eridogu
Lifulo (Ta dsu shau)
Kulue
425
St. Vladimir B.
Tudogu
Avvakum or Vai fu dsin
1067
Sidogu
480
Olgi
C. Sobor
Permskaya
Novinka
Fudin
Tuge Sandogu Farm
R
I
A

UM

Tolo
Makhai
Mokhu
Namchikhak
45°
Tsachang
Chileng
Karaltu manka
Hwanut
Bekherenkhit
G
Wosta ail
Chiling ail
Tsurka sume
Boldinsume
Norumo
Yichengtalyntsacha
Nuru
Well
Well
Khamingtala
Tangaryksume
Artankurbuobo
44°
N
O



Shasakai
Shakatai
Nonni R.
Pakiakia
Peushi
Tahu
L
Kaibur
Lake
Siliao
Tsagansume
Manteche
O
Tuniga
Tsakan tome
Sintien
Khabarka(Shensing)
Takwantien
ekherenkhit
Yintaiail
Shirka
Sintien
Sinluntien
Chwan chanpu
Hwai te
Sinnanpu
Tung liao R.
Siaochentse
Kaifukai
Kunchuling Sta
(Gunshu Pass)
Mossin
(Mosing)
Wei miao
Omor
Michanmancha
Borchihotai
Mei kia kero
Wu kiatun
Chwanku
Hweng yu chuan
Bodune chan
(Narahun)
Shilahai
BODUNE
Shanyinfan
Kungkiashan
Sapaitung
Kutien
Liaosin
Chan yentu
Chanlichan
Fantotung
Liulitung
Kirin ula (Sungari)
Kunyintse
Sanshenmiao
Tulokoshan
Amudaer
Chaposili
Putai
Ko ersi lo(Zapuzi)
Altunyuanachai
Dolongorbai
Uburtu
Ambanachai
Chwanhotai
Sungari (Sung hwa kiang)
Tahutun
Sanmatse
Muohocheng
Hui
Ititun R.
Nunan
Puhai Sta
(Wuhai)
Mishatse Sta
Siaopakiatse
Kwancheng-tsu Sta
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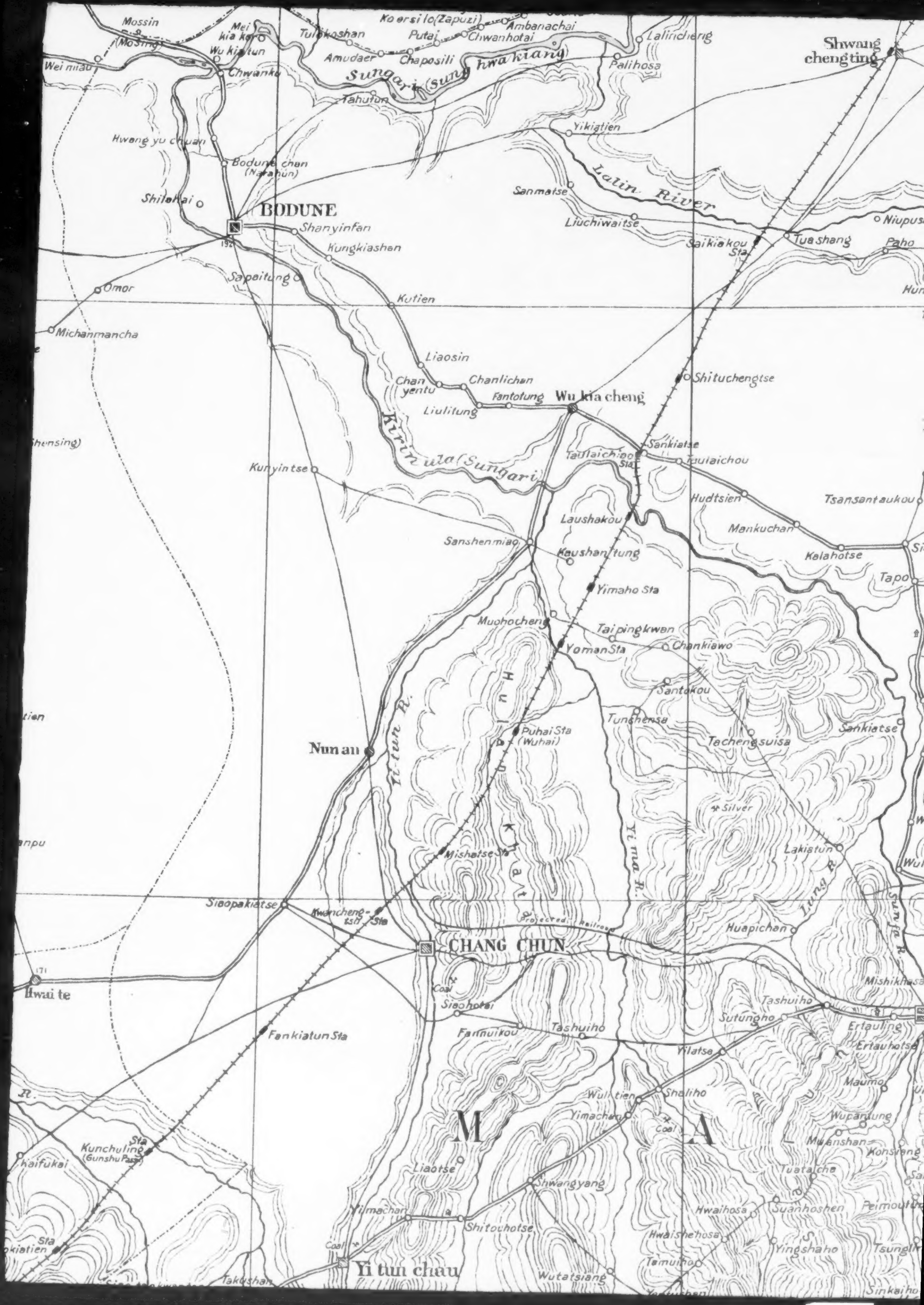
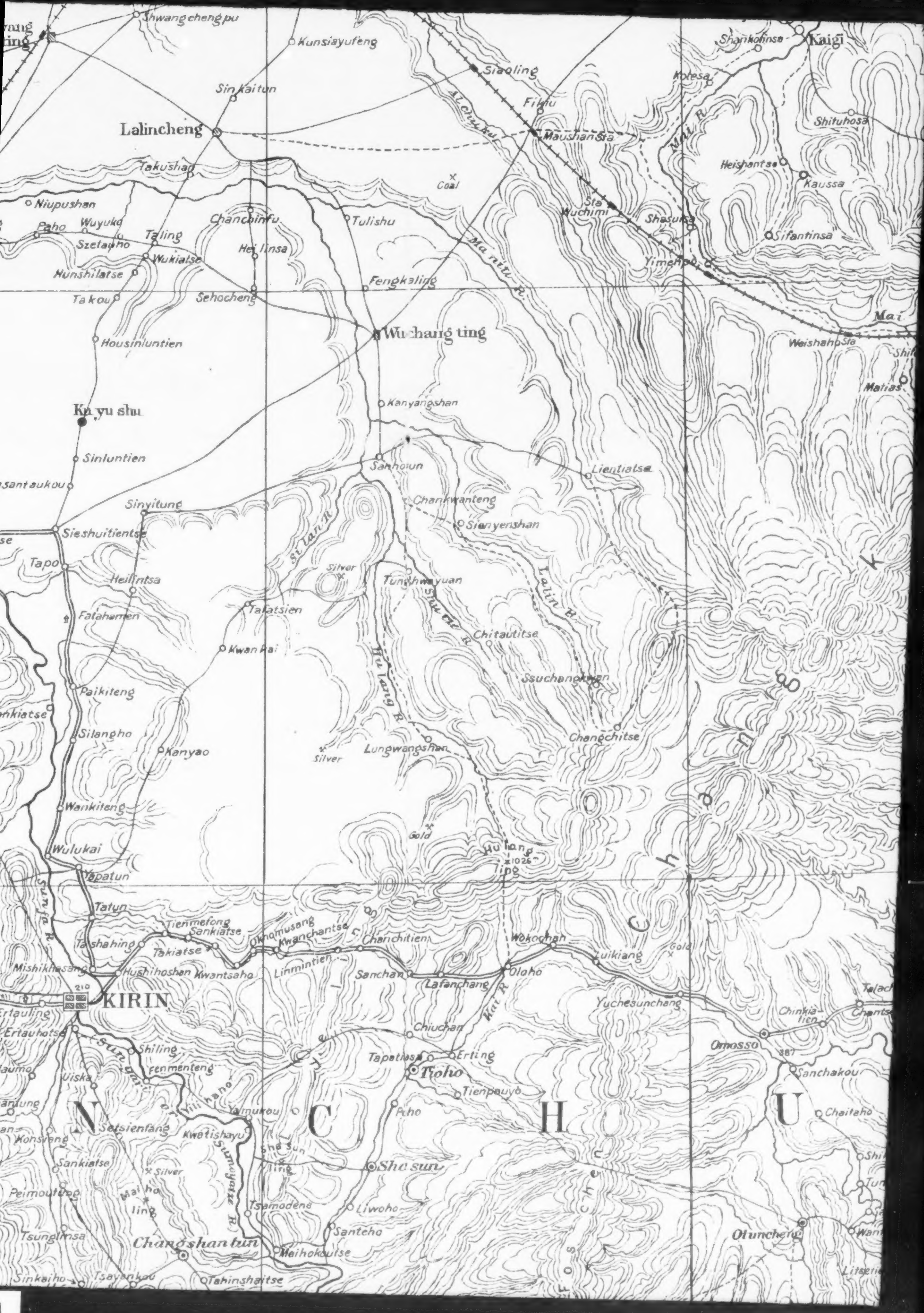
Projected
Coal
Siaohotai
Fanmuikou
Fankiatun Sta
M
Liaotse



Mossin
Wei miau
Mei kia kar
Wu kia tun
Chwanka
Tulakoshan
Amudaer
Chaposili
Putai
Chwanhotai
Ambanachai
Ko ersi lo (Zapuzi)
Sungari (Sung hwa kiang)
Tahutun
Lalinchena
Palihosa
Shwang chengting
Yikiatien
Lalin River
Sanmatse
Liuchiwaitse
Saikiakou Sta.
Tua shang
Niupus
Paho
Hwang yu chuan
Bodune chan (Narahun)
Shilehai
BODUNE
Shanyinfan
Kungkiashan
Sapaitung
Omor
Michanmancha
Kutien
Liaosin
Chan yentu
Chanlichan
Fantotung
Liulitung
Wu kia cheng
Shituchengtse
Kirin ula (Sungari)
Kunyintse
Taulaichiao Sta.
Sankiatse
Taulaichou
Hudtsien
Tsansantaukou
Laushakou
Mankuchan
Sanshenmiao
Kaushantung
Kelahotse
Tapo
Yimaho Sta
Muohocheng
Taipingkwan
Yoman Sta
Chankiawo
Santokou
Tunghensa
Puhai Sta (Wuhai)
Tachengsuisa
Sankiatse
Nun an
Yi tun R.
Hu
Silver
Yi ma R.
Lakistun
Mishatse Sta
Lung R.
Siaopakiatse
Kwancheng-tsu Sta
Projected Railroad
Huapichan
CHANG CHUN
Hwai te
Coal
Siaohotai
Mishikhasa
Tashuiho
Sutungho
Fannuikou
Tashuiho
Ertauling
Ertauhotse
Fankiatun Sta
Yilatsa
Maumo
Wulitien
Shaliho
Yimachan
Wupantung
Coal
M
A
Mwanshan
Konsiang
Kunchuling Sta (Gunshu Pass)
Haifukai
Liaotse
Tuatache
Shwangyang
Yimachan
Hwaihosa
Suanhoshen
Peimoutu
Shitouhotse
Sta kiatien
Coal
Hwaishehosa
Yingshaho
Yi tun chau
Tamuiho
Tsungli
Takushan
Wutatsiang
Sinkaiho

XUM



Shwang cheng pu
Kunsiayufeng
Sin kaitun
Lalincheng
Takushan
Niupushan
Paho
Wuyuko
Szetaoho
Taling
Hunshilatse
Wukiatse
Takou
Sehocheng
Chanchinfu
Hei linsa
Tulishu
Fengkaling
Wuchang ting
Housinluntien
Ku yu shu
Sinluntien
Kanyangshan
Sanhotun
Sinyitung
Sieshuitientse
Tapo
Heilintsa
Fatahamen
Tafatsien
Kwan kai
Paikiteng
Silangho
Kanyao
Wankiteng
Wulukai
Yapatun
Tatun
Sunfa R.
Tashahing
Tienmefong
Sankiatse
Takiatse
Mishikhasang
Hushihoshan
Kwantsaho
Okhomusang
Kwanchantse
Chanchitien
Linmintien
Sanchan
Lafanchang
Wokochan
Oloho
Luikiang
Gold
Yuchesunchang
KIRIN
210
Ertauling
Ertauhotse
Shiling
Fenmenteng
Uiska
Setsienfang
Konsieng
Sankiatse
Silver
Peimoutsop
Mai ho ling
Tsunglinsa
Sinkaiho
Tsayenkou
Tahinshaitse
Changshan tun
Meihokoutse
Tsamodene
Kwetishayu
Sumoyatze R.
Yamukou
She sun ling
She sun
Liwoho
Santeho
Puho
Tioho
Tapatiosa
Erting
Chiuchan
Tienpauyo
Kai R.
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Siaoling
Fikhu
Alchuku R.
Maushan Sta
Coal
Sta Wuchimi
Shasuka
Yimenpo
Ma nitu R.
Shankohnsa
Kaigi
Kotesa
Mai R.
Shituhosa
Heishantse
Kaussa
Sifantinsa
Mai
Weishaho Sta
Matias
Lientiatse
Chankwanteng
Sienyenshan
Si lan R.
Silver
Tunghwayuan
Shu tie R.
Latin R.
Chitautitse
Ssuchangkwan
Hu lang R.
Changchitse
Lungwangshan
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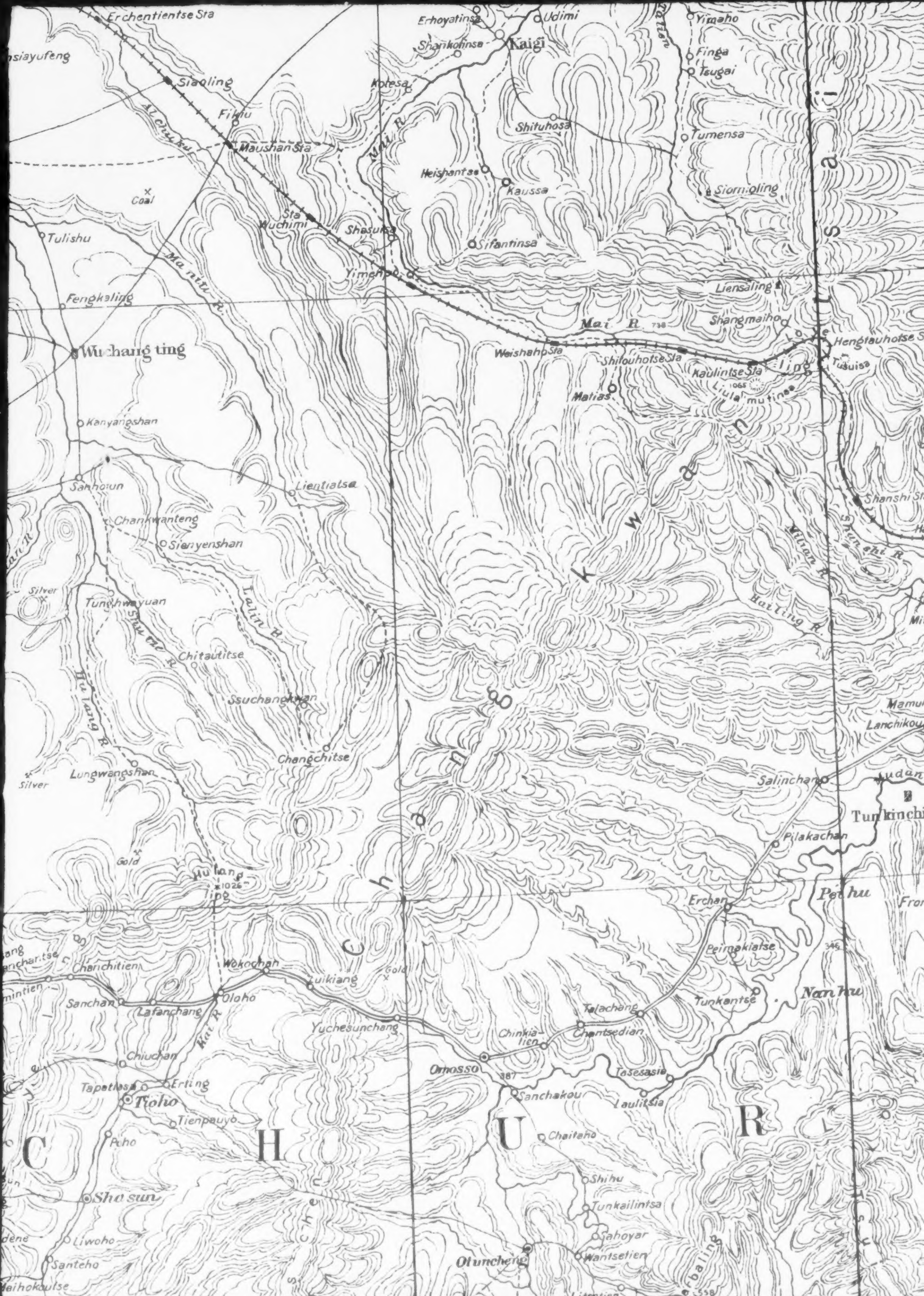
Gold
Hulang ling
1026
Changg
Chinkia lien
Omosso
387
Sanchakou
Chaitaho
Otuncheng



Erchentientse Sta
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Fikiu
Maushan Sta
Coal
Tulishu
Sta Wuchimi
Shasuka
Yimenpo
Fengkaling
Wuchang ting
Kanyangshan
Sanhotun
Lientiatsa
Chankwanteng
Sienyenshan
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Tunghwayuan
Lalin R.
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Ssuchanehan
Changchitse
Lungwangshan
Silver
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Hulang ling
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Gold
Chanchitien
Sanchan
Lafanchang
Oloho
Luikiang
Yuchesunchang
Chiuchan
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Tienpauyo
Poho
Sho sun
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Shihu
Tunkailintsa
Sahoyar
Wantsetien
Otuncheng
Litsetien
Chinkia-lien
Chantsedian
Talachang
Tasesasia
Laulitsia
Erchan
Peimakiatse
Tunkantse
Nanhu
Pilakachan
Salinchan
Tunkinchi
Peihu
Lanchikou
Mamu
Erhoyatinsa
Udimi
Kaigi
Shankolinse
Kotesa
Mai R.
Heishantse
Kaussa
Sifantinsa
Shituhosa
Yimaho
Finga
Tsugai
Tumensa
Siomoling
Liensaling
Shangmaiho
Mai R.
738
Weishaho Sta
Shitouhotse Sta
Kaulintse Sta
Matias
Liula mutinsa
1065
Hengtauhotse
Tusuisa
Shanshi
Milan R.
Hai ling R.
Chang kwan tsai ling


Gold
Gold
Tamurzi
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Santauhotse
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Salinho
Oka Shan
Bir
Garku shan
Muren R.
Er chan
Tutomi
Chanchulatsa
Hwashilinsa
Singkalou
Shanshi Sta
Mutankiang Sta
Linghopo
Hailing Sta
Chukiati
Motaushi
Tai ma kou
Kamenshi Farm
Taimakou Sta
Mulin Sta
Makiauho Sta
Mai li ho
Taipingling Sta
Hsilinho Sta
Volinka
Pogranichnaya Sta
Hsiau sui feng Sta
Laku
Oko
Lahuissan
Shiho
Santientse
Hunshiho
Mitian
NINGUTA
Chan lin tsa
Tung kou ling
Pahlavoda Farm
Hsiau sui fun
Wan lu
Mamukiang
Lanchikou
Mudan kiang
Malingho
Schatotien
Tunhinching
Shahosa
Sui fun
Sinker
Frontier Guard Post
Wadsakior
Tasuihu
Mukhden
Frontier Guard Post
Santauhotse
Fort
Kempakensa
Lotokantse
Hung chung
Amatiho
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Kaiho
Pudashe R.
Frontier Guard Post
Wansin
Wansin
Uyimper
Burcha

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Tamurzi
Mudan kiang (Hulcha)
Santau hotse
Salinho
Oka Shan
Garku shan
Er chan
Tutomi
Chanchulstsa
Hwashilinsa
Singkalou
Chukiati
Oko
Motaushi
Shantientse
Hunshiho
NINGUTA
Chan lin tsa
Muren R.
Makiauho Sta.
Mai li ho
Tai ma kou
Kamenshi Farm
Taimakou Sta.
Muhn Sta.
Mulin
Pantavoda Farm
Makiau R.
Taipingling Sta.
Hsilinho Sta.
Pogranichnaya Sta.
Hsiau sui feng Sta.
Ma tsio
Hsiau sui fun
1087
Wan lu kou
Tundahgu
Shahosa
Hsiau sui fun
Sui fun
Tasui fun
Tashu hosa
Lushan
Levada baravasha
Atamanovskoye
Nun cha R.
Puichi
Frontier Guard Post Molodetski
Volinka
Grotekovo Sta.
Liesnaya
Bogusla
Talovy Sta
Andreyovski
Sofie - Alexiejevski
Nadieshdinski
Fadieyevskaya
Konstantinovskaya
Poltavskaya
San cha kou
Sninelnikova
Alexiye Nikolskaya
Putsilovka
Korsa
Ushagouvski
Krounov
Uresni
Mukhden
Hung chung
Pudashe R.
Hung chung (Tumen tsa)
Frontier Guard Post
Lotokantse
Ametiho
Kai R.
A
Kaiho
Frontier Guard Post Wansin
Wansin
Uyimper
Takantse
Ambabire
Amba bielaya (Shkotova)
Barabash
Mongu
485
610
914
chatotien


Khanka L.
BOUNDARY LINE
MANCHURIA
SIBERIA
Khanka L.
(Hang kai hu)
Turirog
Frontier Guard Post
Novo-Kachalanski
Ussatchi
Platono-Alexandrovskaya
Siyan
Kommissarovskaya
Lushan
Ilyinskaya
Troitskaya
Kamen ribolov
Astrakhanskaya
Novo Selishche
Smiachi
Zharikova
Lifuncha Farm
Liesnaya
Nesterova
Boguslavski
Talovy Sta
Barenonovskaya
Priluki
Popovka
Khorolskaya
Mo
Dievitsa
Altinovka
Voskresenka
Spasskaya
Yevgenievka Sta
Prokhorovka
Knorring Sta.
Dmitrovka
Krasni kut
Bussovka
Merkushevka
Chernigovka
Muchnaya Sta
Gora Pogodinsa
Telegraph Sta.
Lasareva
Blagodatnaya
Vstriechnaya
Chorvatovo Sta
Novo Shastkovo
Mansovka Sta
Monastirishche
Vosnessenskoye
Novo-Shastkovo
Lipovtsi
Dubki
Utesni
Galenka
Pavlovka
Lalichi
Obrazherevski
Nevelskaya
Kremovo
Shiriayevka
Orlova
Seboka
Anuchino
Gordiey
Ossinovka
Larinskaya
Ivanovka
Kosakevichevo
(Lorentsova)
Varvarovka
Gora Sokolinaya
Strugovka
Pokrovka
Dubinskaya
Dubininski Sta.
Vosdvizhenskaya
Danilovka
Nikolayevka
Tudogu Farm
Eridogu Farm
Gora Tigrovaya
Nikolskaya
Ivassenkova
Sokrova
Svirednova
Putsilovka
Borissovka
Korsakovka
Kotrichevo Sta
Rakovka
Nikolsk Ussuriiski
Shuang cheng tse
Suifunskaya
Krounovka
Krasni yar
Terekhovka
Baranovski
Novo Khatunichi
Gora Proroke
Dambu
Khandsiadadi Farm
Rasdolnaya
Suntienfu
Nieshina
Veliko-Udobnaya
Mnogo-
Novo-Rossiskaya
Shangdunu
Tahobei Farm
Tudagu
Tigrovaya
Andreyevka
Nadeshdinskaya Sta.
Issayeva
Saw-mill
Khotsun
Maikhinskaya
Brovnichi
Sergieyevka
Shandsuise Farm
Ambabira
Richnoi
Uglovaya
Shkotova
Amba bielaya
(Shkotova)
Bogoroditskaya
Podgorodnaya
Okeanskaya Sta.
Romanovka
Novo Rossiskoye
Kon khousa
Novo-Nieshino
Kasanka
Pinsau
Frolovka
Nikolayevkaya
Sanadvorovka
Mongugai
Riechitsa
Kaul Sta.
Telegraph
Tikhmene
Cloister
Svienta Troitsa
Post-town No3
Pavlo Fedorovski
Shmakovka Sta.
Longmiau
Post-town No 4
Novo-Mikhailovski
Plantage
Komarovka
Kayevski Sta.
Famagu Farm
Suiagina
Dukhovskaya
Gaivoron
Sinkovka
Alexandrovskoye
Drosdov Sta.
Hvalinka
Telegraph Sta
Yakovleva-Ili
Sissoyavka
Petropavlovka
Gora chornaya
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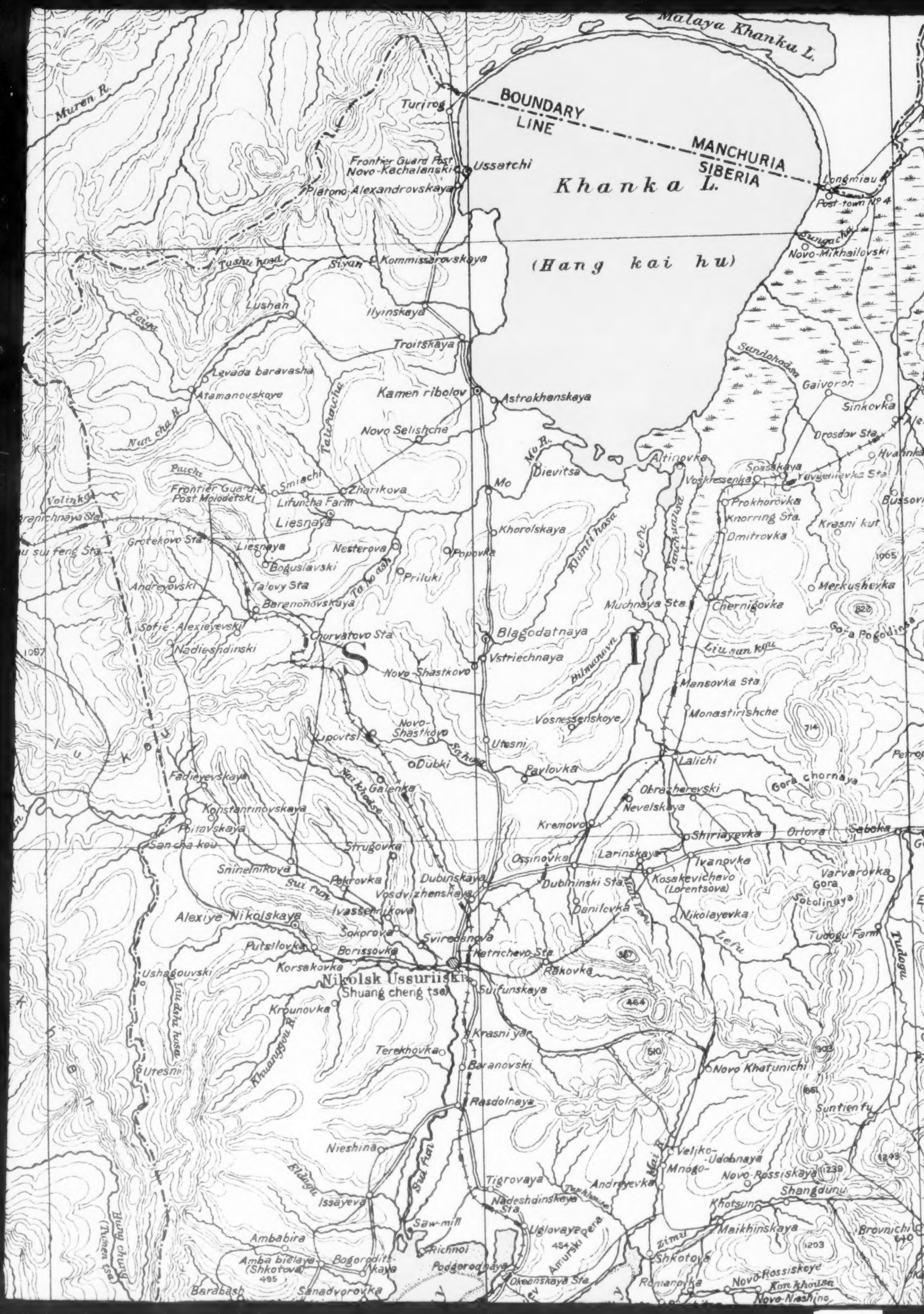
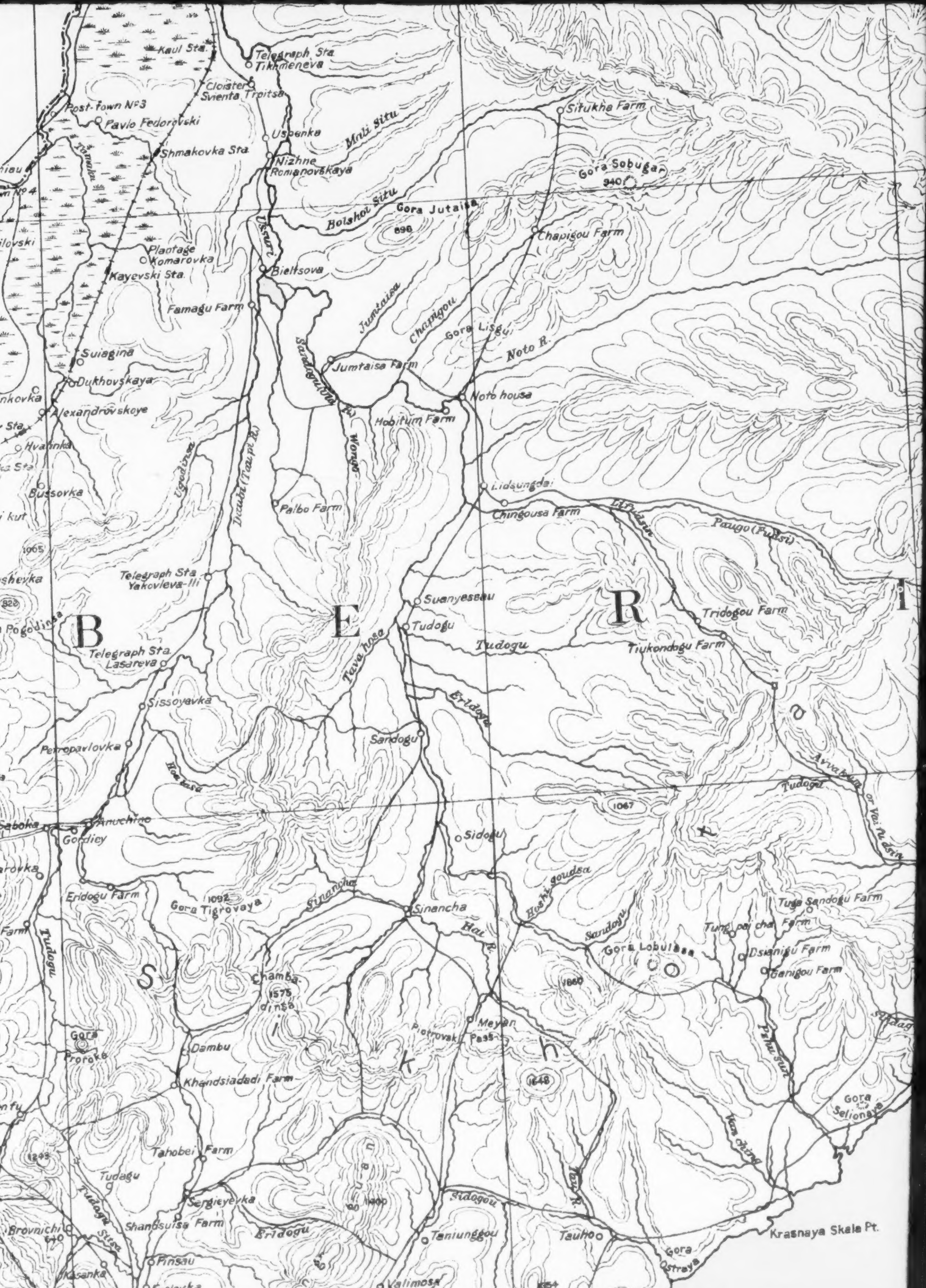


Malaya Khanka L.
Muren R.
Turirog
BOUNDARY LINE
MANCHURIA
SIBERIA
Frontier Guard Post
Novo-Kachalanski
Ussatchi
Platono-Alexandrovskaya
Khanka L.
(Hang kai hu)
Longmiau
Post-town No 4
Sungacha
Novo-Mikhailovski
Tushu hoza
Siyan
Kommissarovskaya
Lushah
Ilyinskaya
Troitskaya
Levada baravasha
Atamanovskoye
Kamen ribolov
Astrakhanskaya
Sandohodsa
Gaivoron
Sinkovka
Novo Selishche
Drosdov Sta
Nun cha R.
Mo R.
Dievitsa
Altinovka
Spasskaya
Yevgenievka Sta
Voskresenka
Frontier Guard Post Molodetski
Smiachi
Zharikova
Lifuncha Farm
Mo
Prokhorovka
Knorring Sta.
Volinka
Granichnaya Sta
Liesnaya
Khorolskaya
Dmitrovka
Krasni kut
Grotekovo Sta
Nesterova
Popovka
Boguslavski
Priluki
Andreyovski
Talovy Sta
Merkushevka
Baranonovskaya
Muchnaya Sta
Chernigovka
Sofie-Alexieyevski
Churvatovo Sta
Blagodatnaya
Gora Pogodinsk
Nadieshdinski
Liu san kou
Vstriechnaya
Novo-Shastkovo
Mansovka Sta
Monastirishche
Vosnessenskoye
Novo-Shastkovo
Lipovtsi
Utesni
Dubki
Lalichi
Pavlovka
Gora chornaya
Galenka
Fadieyevskaya
Obrazherevski
Nevelskaya
Konstantinovskaya
Kremovo
Poltavskaya
Shiriayevka
Orlova
Seboka
San cha kou
Strugovka
Ossinovka
Larinskaya
Ivanovka
Sninelnikova
Pokrovka
Dubinskaya
Dubininski Sta.
Kosakevichevo
(Lorentsova)
Varvarovka
Gora Sobolinaya
Vosdvizhenskaya
Ivassenikova
Alexiye Nikolskaya
Danilovka
Nikolayevka
Lefu
Sokorova
Svireosnova
Tudogu Farm
Tudogu
Putsilovka
Borissovka
Ketrichevo Sta
Rakovka
Korsakovka
Ushagouvski
Nikolsk Ussuriiski
Shuang cheng tse
Suifunskaya
Krounovka
Krasni yar
Terekhovka
Utesni
Baranovski
Novo Khatunichi
Rasdolnaya
Suntien fu
Nieshina
Veliko-Udobnaya
Mnogo-
Novo-Rossiskaya
Tigrovaya
Andreyevka
Shangdunu
Issayeva
Nadeshdinskaya Sta
Khotsun
Saw-mill
Uglovaya
Maikhinskaya
Brovnichi
Ambabira
Amba bielaya
(Shkotova)
Bogoroditskaya
Richnoi
Podgorodnaya
Amurski Pera
Shkotova
Novo-Rossiskoye
Barabash
Sanadvorovka
Okeanskaya Sta
Romanovka
Novo-Nieshino
Hung chung
(Tumen tse)


Kaul Sta.
Telegraph Sta.
Tikhmeneva
Cloister
Svienta Troitsa
Post-town No 3
Pavlo Fedorovski
Situkha Farm
Uspenka
Mnli Situ
Shmakovka Sta.
Nizhne
Romanovskaya
Gora Sobugar
940
Bolshoi Situ
Gora Jutaisa
898
Ussuri
Chapigou Farm
Plantage
Komarovka
Kayevski Sta.
Bieltsova
Famagu Farm
Jumtaisa
Chapigou
Gora Lisgu
Noto R.
Suiagina
Jumtaisa Farm
Dukhovskaya
Noto housa
Alexandrovskoye
Hobitum Farm
Wongo
Hvalinka
Bussorka
Lidsungdai
Palbo Farm
Chingousa Farm
Paugo (Fulsi)
1065
Telegraph Sta.
Yakovleva-Ili
Suanyessau
820
B
E
R
I
Tudogu
Tridogou Farm
Telegraph Sta.
Lasareva
Tava hosa
Tiukondogu Farm
Sissoyevka
Eridogu
Sandogu
Petropavlovka
Tudogu
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Anuchino
Gordiey
Sidogu
Eridogu Farm
Gora Tigrovaya
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Tuga Sandogu Farm
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Sandogu
Gora Lobulasa
Dsianigu Farm
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1648
Gora
Selionaya
Tahobei Farm
Tudagu
Sergieyevka
Sidogou
Shandsuisa Farm
Eridogu
Taniunggou
Tauhoo
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Brovnichi
Pinsau
Kasanka
Gora
Ostraya
Frolovka
Valimosa
782

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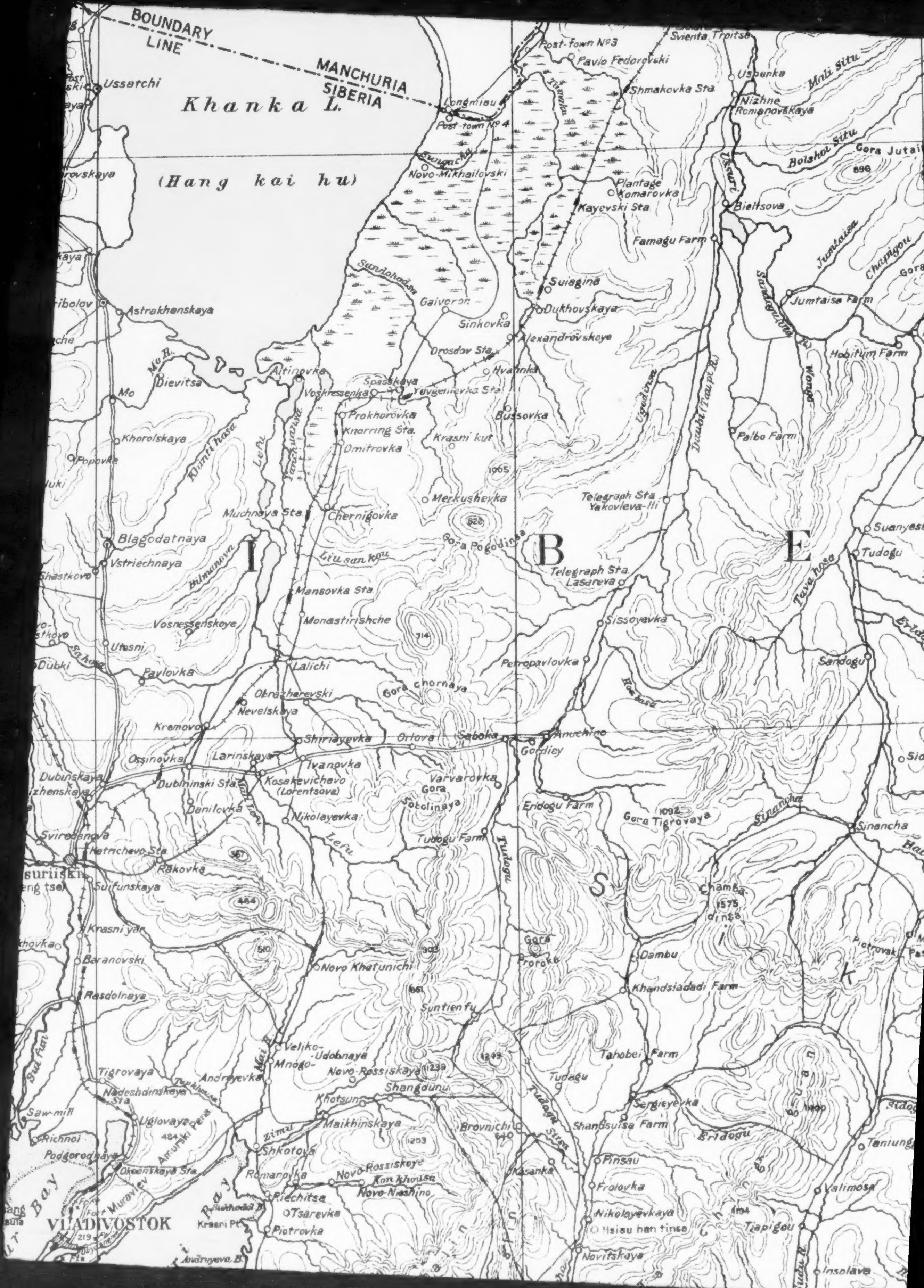
BOUNDARY LINE
MANCHURIA
SIBERIA
Khanka L.
(Hang kai hu)
Ussatchi
Post-town No 3
Pavlo Fedorovski
Svienta Troitsa
Uspenka
Mali Situ
Shmakovka Sta.
Nizhne Romanovskaya
Longmiau
Post-town No 4
Sungacha
Novo-Mikhailovski
Bolshoi Situ
Gora Jutai
896
Plantage Komarovka
Kayevski Sta.
Ussuri
Bieltsova
Famagu Farm
Juntaisa
Chapigou
Sundohodsa
Suiagina
Dukhovskaya
Gaivoron
Jumtaisa Farm
Astrakhanskaya
Sinkovka
Alexandrovskoye
Drosdov Sta.
Hobitum Farm
Mo R.
Mo
Dievitsa
Altinovka
Hvalinka
Spasskaya
Voskresenka
Yevgenievka Sta.
Bussovka
Wongo
Prokhorovka
Knorring Sta.
Dmitrovka
Krasni kut
Palbo Farm
Khorolskaya
Popovka
Khinti hosa
Lefu
Yanchuanisa
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Merkushevka
Telegraph Sta. Yakovleva-III
Muchnaya Sta.
Chernigovka
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Blagodatnaya
Vstriechnaya
Gora Pogodinsa
Liu san kou
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Hilmanuwa
Telegraph Sta. Lasareva
Tava hosa
Mansovka Sta.
Monastirishche
714
Sissoyavka
Vosnessenskoye
Utesni
Dubki
Pavlovka
Lalichi
Petropavlovka
Sandogu
Gora Chornaya
Obrazherevski
Nevelskaya
Kremovo
Shiriayevka
Orlova
Saboka
Anuchino
Gordiey
Ossinovka
Larinskaya
Ivanovka
Dubinskaya
Dubininski Sta.
Kosakevichevo (Lorentsova)
Varvarovka
Gora Sokolinaya
Danilovka
Nikolayevka
Eridogu Farm
1092
Gora Tigrovaya
Sinancha
Svirebnovka
Ketrichevo Sta.
Tudogu Farm
Tudogu
Rakovka
Suifunskaya
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Chamba dinsa
1575
Krasni yar
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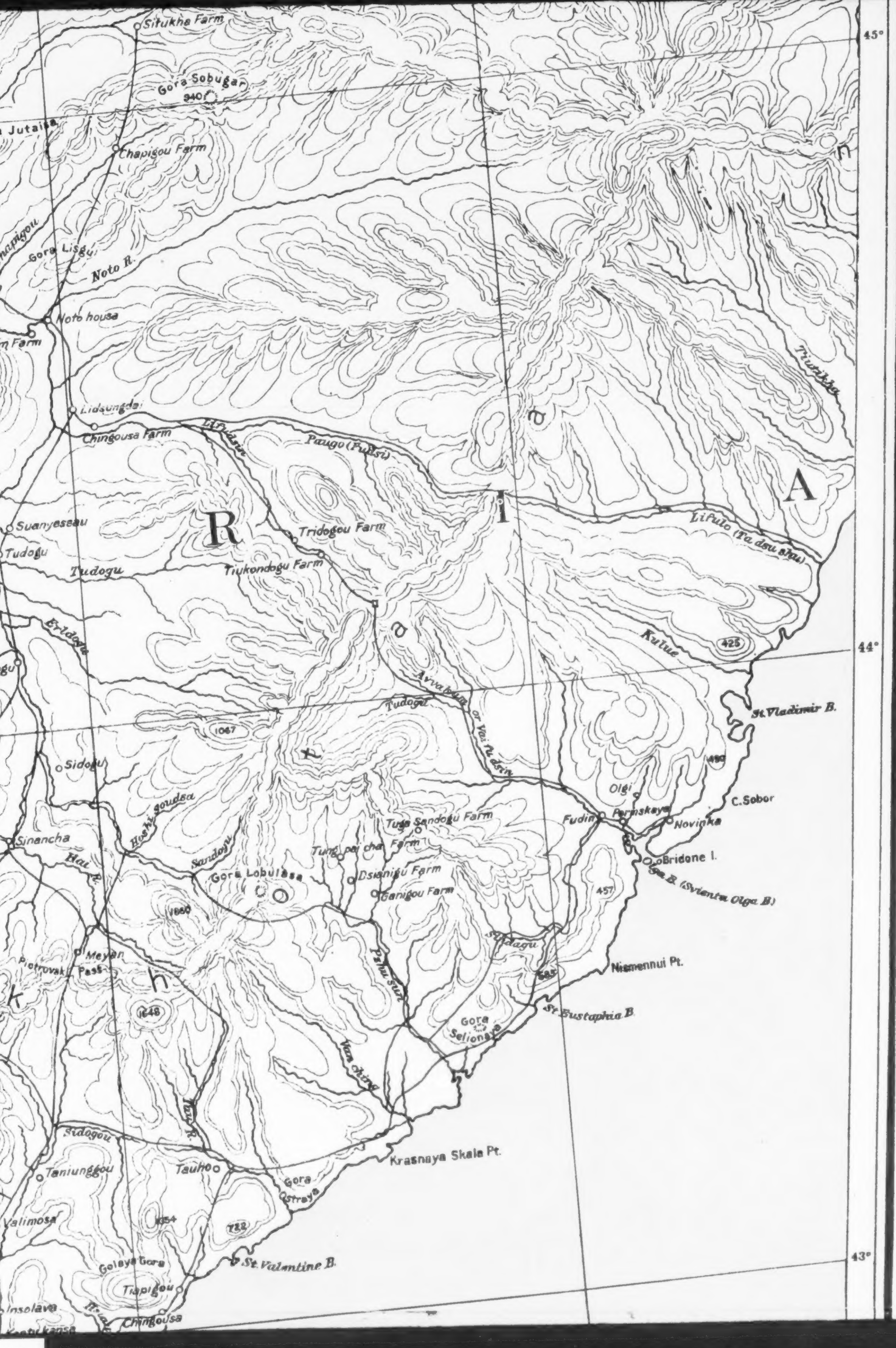
902
Gora Proroke
Dambu
Baranovski
Novo Khatunichi
Pietrovaki
K
Rasdolnaya
661
Khandsiadadi Farm
Suntienfu
Veliko-Udobnaya
Mnogo-
Tahobei Farm
Tigrovaya
Andreyevka
Novo-Rossiskaya
1239
1243
Tudagu
Nadeshdinskaya Sta.
Shangdunu
Sergieyevka
1400
Saw-mill
Uglovaya
Khotsun
Maikhinskaya
Shandsuisa Farm
Eridogu
Taniung
Richnoi
Amurski Pena
Zimu
Brovnichi
1203
Podgorodnaya
Shkotova
Okeanskaya Sta.
Novo-Rossiskoye
Pinsau
Romanovka
Kon khoisa
Kasanka
Novo-Nieshino
Frolovka
Valimosa
Riechitsa
Tsarevka
Nikolayevkaya
Fort Muraviev
VLADIVOSTOK
Krasni Pt.
Pietrovka
Hsisu han tinsa
Tiapigou
Novitskaya
Andreyeva B.
Insolave



45°
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Situkha Farm
Gora Sobugar
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Jutaisa
Chapigou Farm
Gora Lisgu
Noto R.
Noto housa
Lidsungdai
Chingousa Farm
Lifudsin
Paugo (Fudsi)
Tiuvikha
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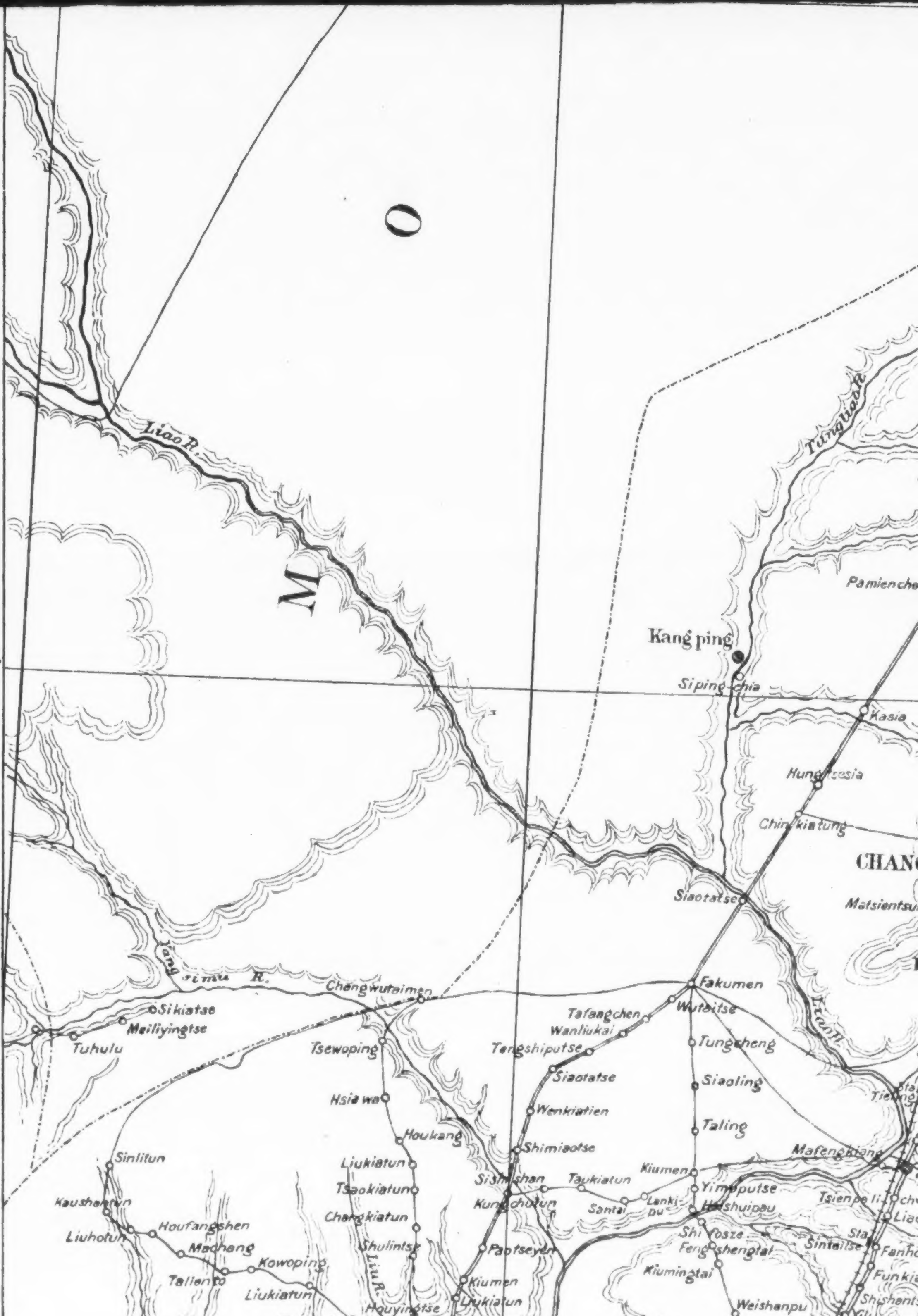
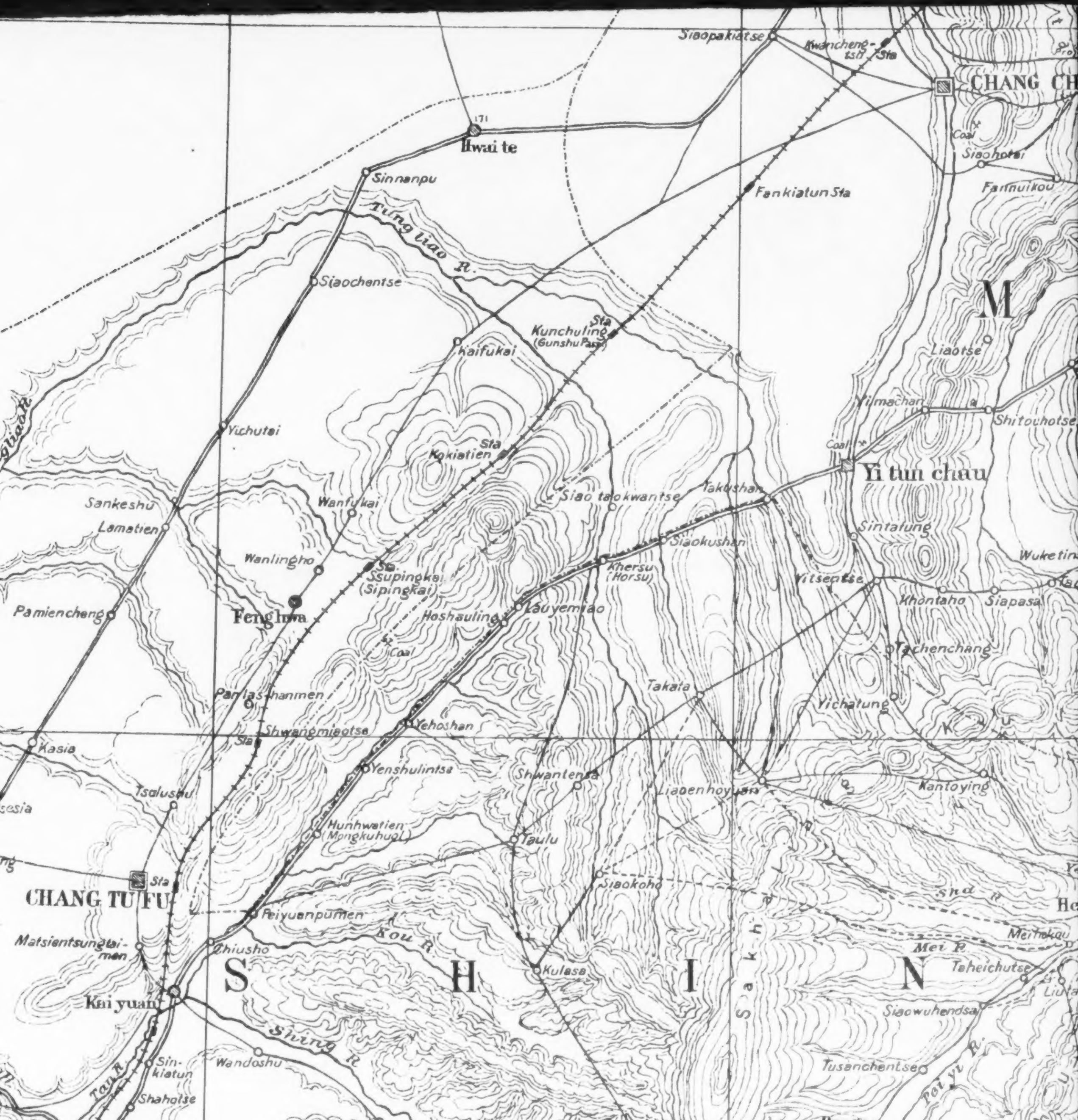
Lifulo (Ta dsu shu)
Suanyeseau
Tudogu
Tudogu
Tridogou Farm
Tiukondogu Farm
Eridogu
Kulue
425
St. Vladimir B.
Avvakuma or Vai fu dsin
Tudogu
1067
r
Sidogu
490
Olgi
C.Sobor
Fudin
Permskaya
Novinka
Bridone I.
Olga B. (Svienta Olga B.)
Hoshi goudsa
Tung Sandogu Farm
Tung pei cha Farm
Sinancha
Hai R.
Sandogu
Gora Lobulasa
o
Dsianigu Farm
Ganigou Farm
457
1680
Meyan
Pietrovak Pass
h
k
Pahu sun
Sidagu
585
Nismennui Pt.
St. Eustaphia B.
1648
Gora Selionaya
Vaa ching
Sidogou
Tau R.
Krasnaya Skala Pt.
Taniunggou
Tauho
Gora Ostraya
Valimosa
1054
722
St. Valentine B.
Golaya Gora
Tiapigou
Insolava
Chingousa



Second Division. General Staff, (Military Information Division) Washington, April 1905.



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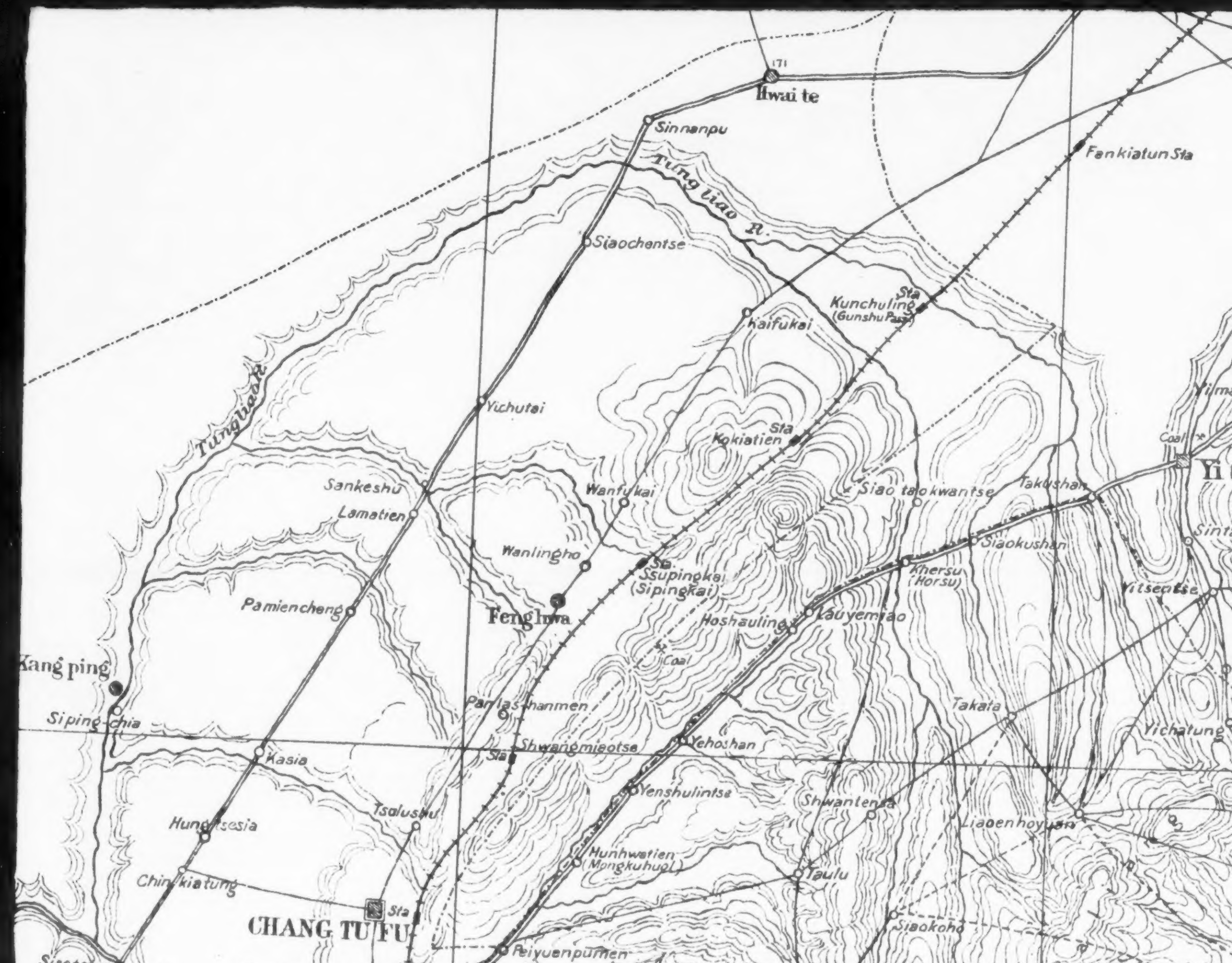

gton, April 1905.

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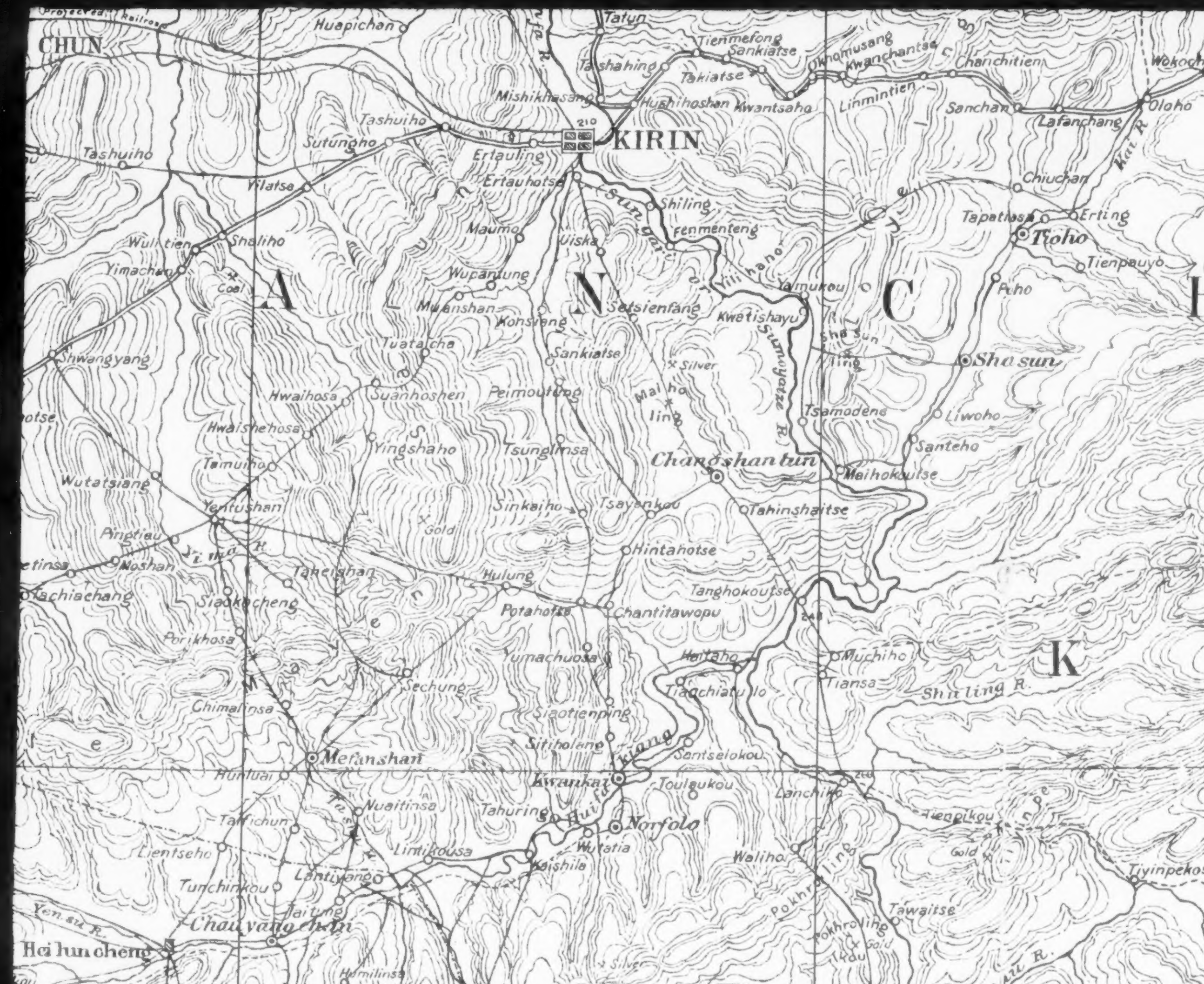
CHUN
KIRIN
Huapichan
Tatun
Tienmefong
Sankiatse
Tashahing
Takiatse
Okhomusang
Kwanchantse
Chanchitien
Wokoch
Mishikhasang
Hushihoshan
Kwantsaho
Linmintien
Sanchan
Lafanchang
Oloho
Tashuiho
Sutungho
Ertauling
Ertauhotse
Yilatse
Shiling
Chiuchan
Tapatiase
Erting
Tioho
Tienpauyo
Fenmenteng
Maumo
Uiska
Wulitien
Shaliho
Yimachen
Coal
Wupantung
Yamukou
Poho
A
N
C
Mwanshan
Konsiang
Setsienfang
Kwetishayu
Sha sun ling
Sha sun
Tuatacha
Sankiatse
Silver
Shwangyang
Hwaihosa
Suanhoshen
Peimoutung
Mai ho ling
Sumayatse R.
Tsamodene
Liwoho
Santeho
Hwaishehosa
Yingshaho
Tsunglinsa
Changshantun
Maihokoutse
Tamuiho
Wutatsiang
Yentushan
Sinkaiho
Tsayenkou
Tahinshaitse
Gold
Pingtiau
Noshan
Hintahotse
Taheishan
Siaokocheng
Hulung
Tanghokoutse
Tachiachang
Potahotse
Chantitawopu
Porikhosa
Yumachuosa
Muchiho
K
Sechung
Haitaho
Tiachiatu
Tiansa
Shiling R.
Chimalinsa
Siaotienping
Sitiholene
Santselokou
Metanshan
Huituai
Kwankai
Touleukou
Lanchiho
Nuaitinsa
Tahuring
Norfolo
Taifichun
Tienpikou
Lientseho
Lintikousa
Wutatia
Waliho
Gold
Kaishile
Tiyinpekos
Tunchinkou
Lantiyang
Pokhroling
Yen su R.
Taitung
Tawaitse
Chau yang chin
Hei lun cheng
Pokhroling
Gold
Silver
Hamilinsa
Pinganchwang
Tachanyuan
Er tau R.
G
Yalijho
Lishikou
Nitacha
Louchan
Silver
Shilowaitse
Ercha
Kaurnouca
Yushiho tse ngo ling
Hamiho'se
Taipingkou
Tumen Yun fa R.
Yenseshau
Tienseshau
Nar chun
Sze chu leng
Tiensaihosa
Erdakou
Chitsienho
Kasachepesa
Siaotamping
Taliensa
Liuhochen
Siachen Kou
Wutietia
Liaoho
Lankouliu
Coal
Lo ku
Naishan
Shankoutse
Takushantsa
Mulankou
Wu yen kautse
Siaosichar
Yutaying
Siachensa
Sapeitsa
Setsori
Tasichar
Tanhokou
Suanhosa
Siaokushantsa
Lien kou
Kuntsinai
126°
127°

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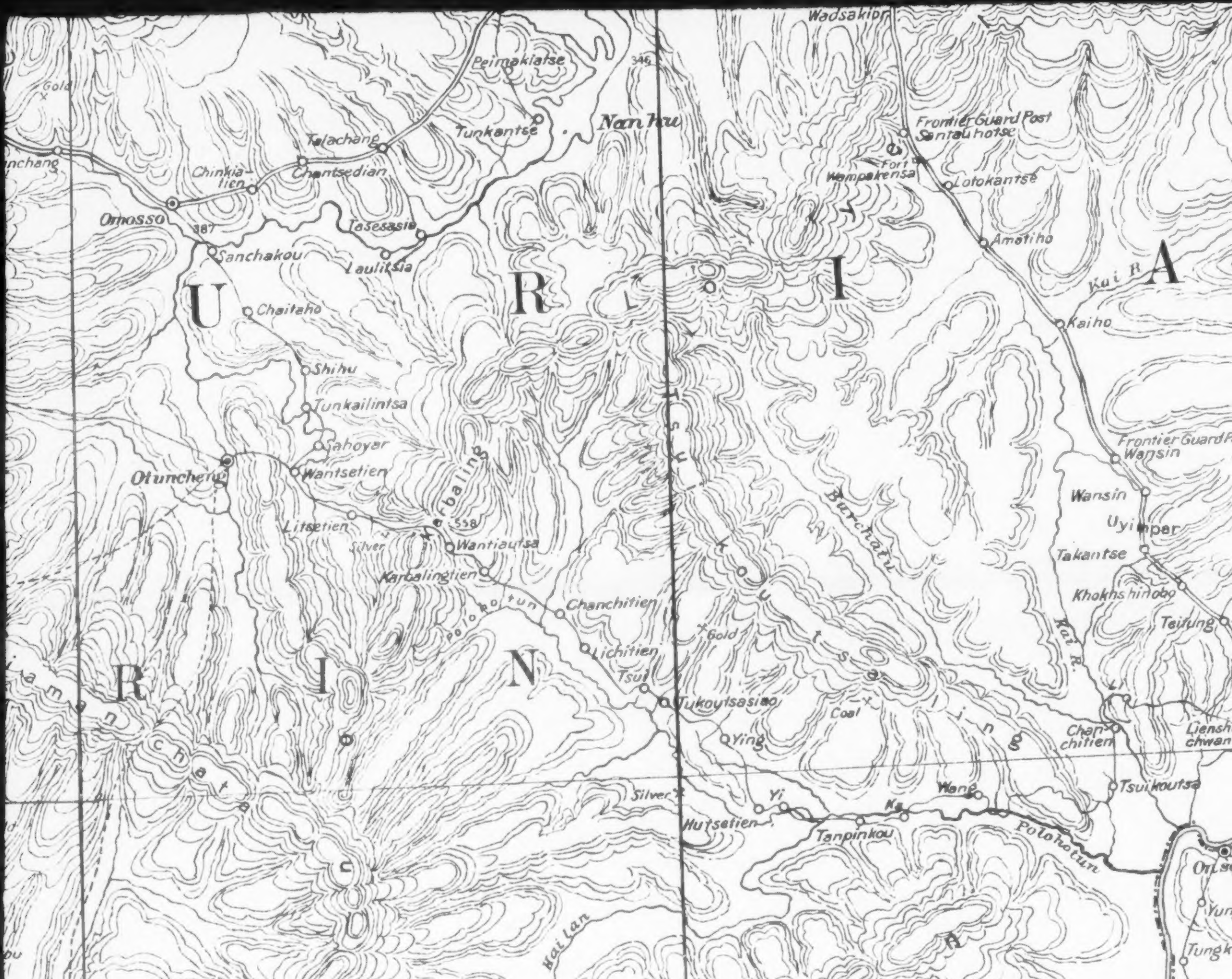
1905."

SCALE OF MILES

10 5 0 10 20 30 40 5

HEIGHTS IN METERS.

M



SCALE OF MILES

10 5 0 10 20 30 40 50 60

HEIGHTS IN METERS.

Nikolsk Ussuriis
Shuang cheng tse
Putsilovka
Borissovka
Korsakovka
Ushagouvski
Krounovka
Terekhovka
Uresni
Nieshina
Issayeva
Ambabira
Amba bielaya
(Shkotova)
Bogorodits-
kaya
Sanadvorovka
Barabash
Mongugai
Popovagora
Peschang
Peninsula
Mongugaiski
Almasovka
Bogoslovka
Amur
Vishn Sedimi
Kedrovayapad
Cherkaskaya
Lomonossov
Peninsula
Rinda I.
(Popov I.)
Brussia
Yankovski
Sedimi B.
Slavianka
Reineke I.
Shau mu ta
(Rikord I.)
Adiminski
Adimi
Verchn
Star. Slavianka
Nishn
Antipenko I.
Trifolko I.
Karamti
Yeltukhin I.
Sibiriakova I.
Samgari
Chapigou
Segetura
Verkhni Yanchiho
Star. Ryesanovka
Sukanovka
Klerka Pt.
Stenin or Redcliff I.
Tisenho
Baranovka
Gladkaya
Novo
Kiyevskoye
Expedition B.
Possiet (Novgorodski)
Gorslikov B.
Rimskogo Korsakov Is
Goliye I.
Astafieva B.
(Pio
Peter
Possiet Bay
Gamova Pt.
Mukhden
Pan-ling
Pudashe R.
Hung chung
Hung chung
(Tumen tsa)
Frontier Guard Post
Wangsin
Teitung
Shatou R.
Michan R.
Michan
Panling Pass
Lienshui
chwantsa
Tantsiong
Pauvantsun
Shuengfatien
HUNG CHUNG
Liutshihoga
Hung chung (Hunchi R.)
Chin Frontier Guard
Post Hung Chung
Fatashi
Yanchiho
Onseng
Siuntsing
Yung
Tungkwang
Shifung
Fantang
Kauling
Tumen
Frontier Guard Post
Tagadeni
Savelovka
Sekbasani
Kionghung
(KigenPu)
Oshurkova
Hanchi
Sarietshe
Chechon
Piotrova
Tunedshiko Pass
Aodi
Dodori
Tutakoli
Varsongali
Kalevala R.
Furugelma I.
Panlian-
tyichen
Wautai
Skala Butakova
(Butakov Rocks)
Hingyeng
Lifungpau
Podgornaya
Gora Shilang
1285
Griady
Hoiriang
Ongi (Kanching)
Kirkumi
Krasniyar (Krasnoyeselo)
Sichuilo
Moyai
Pongwitiem
Gashkevich B.
Boida
C. Fontinia
C. Sessuro
Bielaya skala
Kolonchi
Dokuga
Egerman B.
Sagore
C. Rodionova
Avvakuma I.
Kornilov B.
Pirang
Anna B.
C. Linden
Namyangong
Puka
130°
131°

Post
Kai R.
A
Kaiho
Mukden
Hung chung
Pudashe R.
Frontier Guard Post Wansin
Wansin
Uyimpar
Takantse
Khokhshinobo
Teifung
Rat R.
Shutok R.
Michan R.
Chanchitien
Lienshbichwantsa
Michan
Paniing Pass
Panling
Tsuikoutsa
Tantsiong
Pauvantsun Shuengfatien
HUNG CHUNG
Liutshihoga
Hung chung (Hunchi R.)
Onseng
Siuntsing
Chin Frontier Guard Post Hung Chung
Yung
Tungkwang
Shifung
Chongseng
Tumen R.
Frontier Guard Post
Tagadeni
Sekbasani
Savelovka
Kionghung (KigenPu)
Fantang
Kauling
Chechon
Tunadshikego Pass
Piotrova
Aodi
Dodori
Tutakoli
Varsongali
Kocham
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Gora Shilong
1285
Hoiriang
Nemeulha
Pongwitiem
Kupungsan
Paemusan
Mureungtap
Palmusan sang
Namuhong
Puka
Panliantychen
Lifungpau
Ongi (Kanching)
Kirkumi
Sichuilo
Moyai
Gashkevich B.
Boida
C. Fontinia
C. Sessuro
Kolonchi
Dokuga
Egerman B.
Bielaya skala
Sagore
Kornilov B.
C. Rodionova
Avvakuma I.
Pirang
Anna B.
C. Linden
Oshurkova
Sarietshe
Hanchi
Fatashi
Novo Kiyevskoye
Verkhni Yanchiho
Yanchiho
Baranovka
Gapsoi
Posiet (Novgorodski)
Expedition B.
Novgorod B.
Rhadshida
Sindafy
Trinity B.
Vityaz B.
Possiet Bay
Reid Pallada B.
Kalewala B.
Skala Butakova (Butakov Rocks)
Furugelma I.
Wautai
Podgornaya
Griady
Krasniyar (Krasnoyeselo)
Segetuira
Samgari
Chapigou
Adiminski
634
Tisenho
Star. Ryesanovka
Sukanovka
Gladkaya
Gorelikov B.
Astafieva B.
Gamova Pt.
Boisman B.
Klerka Pt.
Rimskago Korsakov Is.
Goliye I.
Stenin
Pe
Ushagouvski
Utesni
Hung chung (Tumen tsa)
Mongugaiski
569
Vishn. Sedimi
Utaukou
Cherkaskaya
Brussia
Slavianka
Verchn Adimi
Nishn
Adimi
Antipenko I.
Sibiriakova I.
Trifolka I.
Star. Slavianka
Slavianski B.
Yankovski
Sedimi B.
Lomono Peninsula
Kedrovayapad
Bogoslovka
Almasovka
Popovagora
Mongugai
Barabash
Sanadv
Amba bielaya (Shkotova)
485
Ambabira
Issa
Eldagu
Putsilovka
Korsakovka
Krounovka
Khuanggou R.
Iudshi hosa
130°
131°
60

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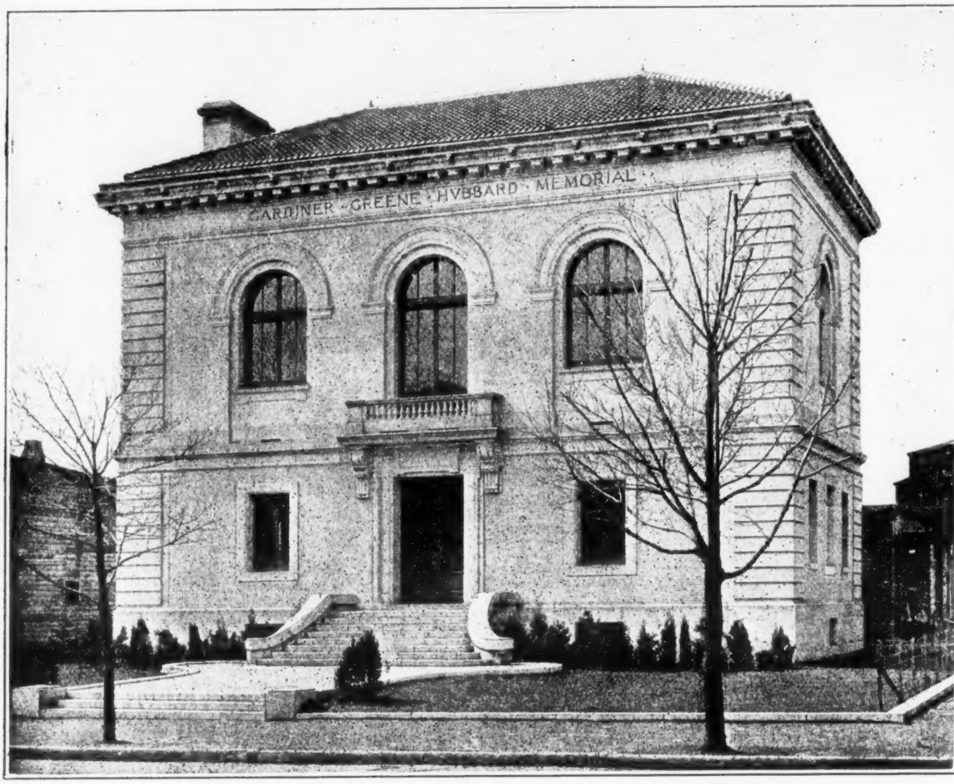

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VOL. XVI, No. 6 WASHINGTON JUNE, 1905

THE NATIONAL GEOGRAPHIC MAGAZINE

FORECASTING THE WEATHER AND STORMS*

BY PROFESSOR WILLIS L. MOORE, LL. D.,

CHIEF UNITED STATES WEATHER BUREAU AND PRESIDENT NATIONAL GEOGRAPHIC SOCIETY.

THE author would urge all intelligent persons to abandon the idea that the weather map is an enigma too difficult for them to solve. To one who will read this chapter once or twice, and carefully follow the charts as they at successive steps illustrate and make clear the text, the daily weather chart will be an object of interest as well as pleasure and profit. Sometimes the problems presented by the map are so simple that one possessed of the most elementary knowledge of its construction can accurately forecast the character of the coming weather; and again, the most expert forecaster is unable to clearly foresee the impending changes.

Weather maps differ as much as do the members of the human family; no two are precisely alike, although they may be similar in their fundamental characteristics. Some are so radically dissimilar to others that it requires but a glance to learn that similar weather cannot follow both. Weather forecasting may be fairly placed upon a plane with the theory and practice of medicine. The forecaster is in a degree guided in his calculations by symptoms, and he is able to diagnose the atmospheric conditions with about the same degree of accuracy that the skilled physician is able to determine the bodily condition of his patient. He is able to forecast changes in the weather with rather more certainty than the physician can predict the course and the result of a well-defined disease. While but less than a century ago we knew not whence the winds came nor whither they went, we are now able, through the aid of daily meteorological observations and the telegraph that joins our places of observation by an electric touch, to trace out the harmonious operations of many physical laws that previously were unknown, and that determine the goings and the comings of the winds, and the sequence in which weather changes

occur; but in weather forecasting it will never be possible to attain the accuracy acquired by astronomers in predicting the date of an eclipse or the occurrence of celestial events.

In this connection it is interesting to note that at the time of the founding of the first of the Thirteen Colonies, at Jamestown, Virginia, in 1607, practically nothing was known of the properties of the air or of the methods of measuring its phenomena. Today, at over 200 stations in the United States, Canada, and the West Indies, electrically recording automatic instruments measure and transcribe, for each moment of time, the temperature, the air pressure, the velocity and the direction of the wind, the beginning and the ending of rainfall, the amount of precipitation, and the duration of sunshine.

It was not until 1643, twenty-three years after the landing of the Pilgrims at Plymouth Rock, that Torricelli discovered the principle of the barometer, and made it possible to measure the weight of the superincumbent air at any spot where the wonderful, yet simple, little instrument might be placed. His great teacher, Galileo, who was so cruelly persecuted for teaching the truth of the Copernican theory and for the invention of the telescope, died without knowing of the barometer. He therefore never understood why "nature abhors a vacuum." But meteorologists as well as astronomers must ever pay homage to his great intellect, for, among many other valuable inventions, he discovered the principle of the thermometer. The data from the readings of the barometer and the thermometer form the foundation of meteorological science. Their inventors as little appreciated the value of their discoveries as they dreamed of the great empire then just rising from the mists of the western seas, which should come into existence and first use their instruments to detect the inception of storms.

THE RESEARCHES OF BENJAMIN FRANKLIN

About one hundred years after the invention of the barometer Benjamin Franklin, statesman, diplomat, patriot, and scientist, divined that northeast storms were caused by atmospheric disturbances located to the southwest of the regions experiencing the northeast winds. He compared the movement of the air to water held in a canal by a gate at the lower end. When the gate is opened the water nearest it moves first, then that next higher up, and so on, until motion is imparted to the water at the far end of the canal. His simile does not explain what actually occurs, but it closely approaches the truth. It was prophetic that this idea should come to him long before any one had ever seen charts that show weather observations simultaneously taken at a system of stations scattered throughout a broad area. His theory was equally as important as his act of drawing the lightning from the clouds and identifying it with the electricity of the laboratory, but his contemporaries thought little of it and it was soon forgotten.

It will aid in understanding the cyclonic motion of storms, which will be fully explained a little farther along in this chapter, to learn how Franklin came to reach his conclusions as to the cause of the northeast winds. He had arranged with his brother in Boston to take observations of a lunar eclipse at the same time that he himself would take them in Philadelphia. Early on the evening of the eclipse an unusually severe northeast storm began at the latter place, lasted many hours, and prevented Franklin from getting observations. As the wind blew fiercely from the northeast, he reasoned that of course the storm came from that direction, and that his brother's views in Boston also were obscured. What was his surprise, a few days later, to receive word that the

night was clear and that good observations were secured, but that a severe northeaster began the next morning. He then sent out many inquiries to stage stations, and learned that at all places southwest of Philadelphia the storm began earlier, and that the greater the distance the earlier the beginning, as compared with its advent in Philadelphia. Northeast of Philadelphia the time of beginning was later than at that city, the storm not reaching Boston until twelve hours after its commencement at Philadelphia.

Franklin's analogy of the water is all right so far as it goes. But if, instead of the canal, he had imagined a broad ocean, and in place of the gate he had located a maelstrom a hundred miles wide in the center of the ocean, toward which the waters within a circle a thousand miles in diameter were moving, first slowly and directly toward the center, then with accelerating velocity and increasing deflection to the right of the center, and finally faster and faster as they drew near and gyrated with fearful speed about the orifice down which they must plunge, he would have gained a clearer idea of the motions of the air in a large cyclonic storm, except that to make the analogy perfect it is necessary to invert the maelstrom and have the upper surface of the ocean face downward upon the land to represent the atmosphere, and then the maelstrom, with its vast system of in-flowing currents, must have a movement of translation eastward.

The northeast hurricane that swept the region from Boston to Philadelphia was caused by the suction exercised by a cyclonic storm advancing from the southwest, which drew the air rapidly from Boston toward Philadelphia, while the source of the attraction—the center of the cyclone—was several hundred miles to the southwest of the latter place. The velocity of the northeast winds increased as the center of the cyclone came nearer and nearer, until the winds reached the force of a hurricane. When the center of the storm reached the vicinity of Philadelphia the winds suddenly became variable and light, and as the center of the disturbance passed the winds arose as quickly as they had subsided, but with this difference: they now blew from some westerly point indirectly, or spirally toward the center of the storm that was passing eastward, and diminished in force as the center gained distance.

Had the telegraph been in existence in Thomas Jefferson's day he doubtless would have conceived the idea of forecasting the weather. In conjunction with his friend, James Madison (afterward Bishop), he conducted a series of weather observations, which were begun in 1771 and continued during the stirring times of the Revolution. Madison was near the sea, at Williamsburg, the colonial capital of Virginia; Jefferson was at Monticello, 120 miles west. They took simultaneous observations for several years, until the British ransacked Madison's house and carried off his barometer. By comparing observations they discovered that barometric and thermometric changes occurred at Monticello three or four hours before they did at Williamsburg.

THE BEGINNING OF THE AMERICAN WEATHER SERVICE

Although American scientists were the pioneers in discovering the progressive character of storms and in determining the practicability of forecasting the weather, the United States was the fourth country to give legal autonomy to a weather service. But it would require an international service, embracing all the countries of Europe, to equal the service of the United States in extent of the area covered. Furthermore, forecasts for the countries of western Europe can never cover the time in advance or attain the accuracy of those

made for the region east of the Rocky Mountains on the American continent, because of the ocean that lies to the west of these countries in Europe, from which observations cannot be secured. To be sure, wireless telegraphy may partly relieve the situation, but irregular observations from moving vessels cannot take the place of stable land stations.

At the time of the beginning of the U. S. weather service, in 1870, and for some years thereafter the forecasts and storm warnings were looked upon by the press and the people more as experiments than as serious statements. The newspapers were prone to comment facetiously on them, and many were clamorous for the abolition of the service. We knew nearly as much about the theory of storms then as we do today; but we had never had the opportunity to train a corps of expert forecasters, such as now form a considerable part of the staff of the Chief of the Weather Bureau, and from which he himself was graduated. This could only be done by several years of daily watching the inception, the development, and the progression of storms. After a time mariners began to note that in the great majority of cases storm warnings were followed by dangerous winds and to take heed accordingly. With experience the warnings became still more accurate, until now no port, however small, is without its storm-warning tower, and no mariner sails the seas who does not consult the signals, and no shipper of perishable commodities runs his business a day in the winter without being in touch with the source of cold-wave warnings, and no large grower of fruits or vegetables is content to be excluded from the receipt of the frost forecasts.

Redfield, Espy, Henry, Loomis, Maury, Abbe, and Lapham are the Americans to whom the world owes most for the founding of meteorological science and for the demonstration of the feasibility of weather forecasts.

HOW THE DAILY WEATHER CHART IS MADE

It is essential to a comprehension of the problems involved in the making of forecasts that one gain a knowledge of the methods of gathering meteorological observations and making weather reports. This morning at 8 o'clock—75th meridian time—which, by the way, is about 7 o'clock at Chicago, 6 o'clock at Denver, and 5 o'clock at San Francisco—the observers at about 200 stations scattered throughout the United States and the West Indies were taking their observations, and, with the aid of carefully tested instruments, noting the pressure of the air, the temperature, the humidity, the rainfall or snowfall, and the cloudiness at the bottom of the aerial ocean in which we live, and which, by its variations of heat and cold, sunshine, clouds and tempest, affect not only the health and happiness of man, but his commercial and industrial welfare. By 8.15 the observations have been reduced to cipher for purposes of brevity, and each has been filed at the local telegraph office. During the next 30 to 40 minutes these observations, with the right of way over all lines, are speeding to their destinations, each station contributing its own observations and receiving in return, by an ingenious system of telegraph circuits, such observations from other stations as it may require. The observations from all stations are received at such centers as Washington, Chicago, New York, and other large cities, and nearly all cities having a Weather Bureau station receives a sufficient number of reports from other cities to justify the issuing of a daily weather map.

Before examining the accompanying charts it may be well to glance at the central office in Washington, while the observations are coming in, so as to get

an idea of how the charts are made for the study of the forecast official. From these he gets a panoramic view, not only of the exact conditions of the air over the whole country at the moment of taking the observations one hour before, but of the changes that have occurred in those conditions during the preceding 12 and 24 hours. As fast as the reports come from the wires they are passed to the Forecast Division, where a reader stands in the middle of the room and translates the cipher into figures and words of intelligible sequence. A force of clerks is engaged in making graphic representations of the geographical distribution of the different meteorological elements. On blank charts of the United States each clerk copies from the translator that part of each station's report needed in the construction of his particular chart. One clerk constructs a chart showing the change in temperature during the preceding 24 hours. Broad red lines separate the colder from the warmer regions, and narrow red lines inclose areas showing changes in temperature of more than 10 degrees. The narrow lines generally run in oval or circular form, indicating (as will be shown subsequently) that atmospheric disturbances move and operate in the form of great progressive eddies; that there are central points of intensity from which the force of the disturbance diminishes in all directions.

A second clerk constructs a chart showing the change that has occurred in the barometer during the past 24 hours. As in the construction of the temperature chart, broad, heavy lines of red separate the regions of rising barometer from those of falling barometer. Narrow lines inclose the areas over which the change in barometer has been greater than one-tenth, and so on.

Here, for instance, throughout a great expanse of territory, all the barometers are rising—that is to say, the air cools, contracts, becomes denser, and presses with greater force upon the surface of the mercury in the cisterns of the instruments, thereby sustaining the columns of liquid metal at a greater height in the vacuum tubes. Over another considerable area the barometers are falling, as increasing temperature rarefies and expands the volume of the air, causing it to press upon the instruments with less force. This chart is extremely useful to the forecaster, since, in connection with the general weather chart, it indicates whether or not the storm centers are increasing or decreasing in intensity, and, what is of more importance, it gives in a great measure the first warning of the formation of storms.

A third clerk constructs two charts, one showing the humidity of the air and the other the cloud areas, with the kind, amount, and direction of the clouds at each station. It is often interesting to observe at a station on the cloud chart high cirrus clouds composed of minute ice spiculæ moving from one direction, lower cumulo-stratus composed of condensed water vapor moving from another direction, and the wind at the surface of the earth blowing from a third point of the compass. Such erratic movements of the air strata are only observed shortly before or during rain or wind storms.

A fourth clerk constructs a chart called the general weather chart, showing for each station the air temperature and pressure, the velocity and direction of the wind, the rain or snow fall since the last report, and the amount of cloudiness. The readings of the barometer on this chart are reduced to sea-level, so that the variations in pressure due to local altitudes may not mask and obscure those due to storm formation. Then lines, called isobars, are drawn through places having the same pressure. By drawing isobars for each difference in pressure of one-tenth of an inch the high and the low pressure areas are soon inclosed in their proper

circles. The word "high" is written at the center of the region of greatest air pressure and the word "low" at the center of the area of least pressure. Under the influence of gravity the air presses downward and outward in all directions, thus causing it to flow from a region of great pressure toward one of less. The velocity with which the wind moves from the high toward the low will depend largely on the difference in air pressure. To better illustrate: If the barometer read 29.5 at Chicago, Ill., and 30.5 at Bismarck, North Dakota, the difference of one inch in pressure would cause the air to move from Bismarck toward Chicago so rapidly that after allowing for the resistance of the ground there would remain a wind at the surface of the earth of about 50 miles per hour, and Lake Michigan would experience a severe "northwester."

CYCLONIC STORMS

Chart No. 1 shows a winter storm (cyclone) central in Iowa at 8 a. m., December 15, 1893. The word "low" marks the storm center. It is the one place in all the United States where the barometer reading is the lowest. The heavy, black lines, oval and nearly concentric about the low, show the gradation of air pressure as it increases quite uniformly in all directions from the storm center outward.

The arrows fly with the wind, and, as will be seen, are almost without exception moving indirectly toward the low or storm center, clearly demonstrating the effect of gravity in causing the air to flow from the several regions marked high, where the air is abnormally heavy, toward the low, where the air is lighter. As the velocity of water flowing down an inclined plane depends both on the slope of the plane and on the roughness of its surface, so the velocity of the wind as it blows along the surface of the earth toward the storm center depends on the amount of the depression of the barometer at the center and the resistance offered by surfaces of varying degrees of roughness. The small figures placed at the ends of the arrows indicate wind velocities of six miles per hour and more. At Chicago, where the wind is blowing at the rate of 40 miles per hour, the anemometer is 270 feet high, while at Minneapolis, where the instrument is so low as to be in the stratum whose velocity is restricted by the resistance encountered in flowing over forests to the northward, the rate is not great enough to be marked by a figure. At Chicago and Davenport the wind is blowing against the pressure gradient, away from the low. This is due to the fact that it has flowed swiftly from the south and gained such momentum that it rushes by the storm center before the gradient on the north of the center can overcome its movement and turn it.

Now picture in your mind the fact that all the air inside the isobar (heavy black line) marked 30.2 as it moves spirally inward is rotating about the low in a direction contrary to the movement of the hands of a watch, and you have a very fair conception of an immense atmospheric eddy, or cyclone.

Have you ever watched the placid water of a deep running brook and observed that where it encountered a projecting crag little eddies formed and went spinning down the stream? Well, storms are simply great eddies in the air that are carried along by the general easterly movement of the atmosphere in the middle latitudes of both hemispheres and by the westerly movement of the general circulation in the tropics. But they are not deep eddies, as was once supposed. The low marks the center of an atmospheric eddy of vast horizontal extent as compared with its thickness or extension in a vertical direction; thus a storm condition extends from Washington to Denver in a horizontal direc-

tion, and yet extends upward but four or five miles. The whole disk of whirling air four or five miles thick and 1,500 miles in diameter is called a cyclone or cyclonic system. It is important that a proper conception of this fundamental idea be had, since the weather experienced from day to day depends almost wholly on the movement of these traveling eddies, cyclones, or areas of low pressure.

That one may gain a clear understanding of the difference between the movements of the air in the cyclone and the movement of the cyclone itself, or its translation from place to place, let him picture in his mind the solar system, with all of its planets and their satellites, turning each upon its own axis and pursuing its orbit about the sun, and then imagine the sun also as rotating and as moving forward in space without change in the relation of the planets to the sun, or the satellites to the planets, and he will have less difficulty in comprehending the various phases of the translation of a cyclonic system and the sequence in which the force and the direction of the wind changes; how the wind must blow into the front of the storm in a direction partly or wholly contrary to the movements of the storm itself and into the rear of the storm as it passes away; how the wind increases in velocity as it gyrates spirally about the center and approaches nearer and nearer the region where it must ascend; how centrifugal force, in causing the higher layers of air to move away from the center, tends to cause an accumulation of air about the outer periphery of the storm, which in turn presses downward and impels the surface air inward. This whole complex system of motion moves forward the same as does the sun and his system.

The black round disk indicates that the weather is cloudy at the moment of the observation, and the open disk clear sky. S. and R. stand for snow and rain. The large figures in the four quarters of the cyclone show the average temperature of each quadrant. The greatest difference is between the southeast and northwest sections. This is due in part to the fact that in the southeast quadrant the air is drawn northward from warmer latitudes, and in the northwest quadrant the air is drawn southward from colder latitudes.

Chart II, constructed from observations taken 12 hours later, shows that the storm or cyclonic center, as indicated by the word "low," has moved from central Iowa since 8 a. m. and is now, at 8 p. m., central over the southern point of Lake Michigan. The shaded areas show that precipitation has occurred during the past 12 hours in nearly the entire region covered by the cyclone. Unfortunately for the science of forecasting, precipitation does not show that relation to the configuration of the isobars that temperature, wind velocity, and wind direction do.

Note that none has fallen in the southern portion of Ohio, in northwest Missouri, and in West Virginia and eastern Kentucky, although they are near the storm center, while a fall has occurred in New England, quite remote from the center of barometric depression. These facts illustrate how a forecast of rain or snow may fail for a portion of a state or for a whole state, even though the storm pass over the state and the wind and temperature change precisely as predicted. However, all the places mentioned as failing to receive precipitation were showered upon during the further progress of the storm, except northwest Missouri, as will be seen by referring to chart III of the following morning. The cyclone has continued its course toward the northeast, and has brought the rain area eastward to include nearly the whole Atlantic coast region. The weather has cleared on the west side of the storm.

Charts II and III contain red lines,

which, like the dark shading, do not appear on chart I, which was purposely left clear of these symbols, so that the movement of wind in accordance with pressure gradients could be the better shown. These red lines connect places having the same temperature. Note how, on both charts, they trend from the Atlantic coast northwestward into the southeast quarter of the cyclone, and where they leave the storm center how precipitately they drop away toward the southwest. A cause can be easily found for this by examining the direction of the arrows. In the first case the isothermals are being pushed northward by southerly winds, and in the other forced southward by winds from the northwest. As the cyclone proceeds eastward the regions now under the influence of warm southerly winds will be, in less than 24 hours, on the west side of the storm, and cold northwest winds will sweep over them.

The line of arrows leading from western Wyoming to the center of the storm on chart III shows the place where the cyclonic circulation of wind began that constitutes the storm and the course pursued by the storm center. The small circles surrounding crosses mark the places where the storm was central at each 12-hour interval. The figure above the circle indicates the date, and the letter below evening or morning.

As previously explained, the large figures give the average temperature for each of the four quarters of the storm within a radius of 500 miles from the center. The same information may be gathered from the isotherms, but cannot be so strikingly presented. Now, remembering that the air ascends as it spirally moves around the center, one may see how the cold air of the northwest quarter is mingled with the warm air of the southeast portion, which in each of the three cases presented by the charts so far brought into the discussion is more than three times as warm. On chart III the two quarters are represented—one by 13 degrees and the other by 47 degrees. The mixing of such cold and such warm masses of air and the addition of cold due to expansion as the mixture rises is a fruitful cause of precipitation, but not the only one, for we see that rain has fallen in the Gulf states, as exhibited on chart III, probably only as the result of cold northwest winds flowing into and mingling with the warm air of the south. Precipitation may also occur as the result of the warm humid air of southerly winds underrunning cold and heavier air, and by other processes not yet understood.

ANTI-CYCLONIC STORMS

Attention is now directed to the *anti-cyclone* or high-pressure area shown on these three charts as resting over the Rocky Mountain plateau. Here all the functions of the cyclone are reversed; hence the name anti-cyclone. The air has a downward component of motion at and for a considerable area about the center, instead of an upward component; the winds blow spirally outward from the interior, instead of inward, and are deflected to the left of their initial direction, instead of to the right, and the air is mostly clear, cool, and dry, instead of cloudy, warm, and humid. The center of this high moved but little during the three 12-hour periods, but its area expanded eastward as the low advanced, and if the chart of December 17, 8 p. m., were shown the high pressure would be seen to cover with clear, cool weather the region now embraced within the limits of the low pressure.

These are winter conditions that are being described. The storms are general, not local, as in summer, when the highs and the lows exhibit small differences of pressure, move slowly, and seldom embrace large areas. The summer type of local storms gradually merges into general storms as the heat of sum-

mer wanes, the first general rainstorms usually occurring during the latter part of September. This has given rise to the erroneous idea of an "equinoxial storm."

HOT WAVES

For some reason there come, in summer, periods of stagnation in the drift of the highs and the lows. At such times, if a high sluggishly rests over the south Atlantic Ocean between Bermuda and the coast of the United States and a low over the northern Rocky Mountain region, there will result what is popularly known as a warm wave, for the air, on account of its slightly greater specific gravity, will slowly and steadily flow from the southeast, where the pressure is greater, toward the northwest, where the pressure is less, and, receiving constant accretions of heat from the hot, radiating surface of the earth, without any cyclones to mix the upper and lower strata, will finally attain a temperature almost unbearable to animal life. This superheated condition of the lower stratum in which we live continues until the high over the ocean dies out or drifts away to the east and the low-pressure area in the northwest begins to gyrate as a cyclone and moves eastward, mixing in its course strata of unequal temperatures and precipitating the cool and welcome thunder showers.

COLD WAVES

Chart IV shows the beginning of a cold wave in the northwest on the morning of January 7, 1886. Observe that the heavy, black isobar passing through Montana is marked 30.9, while the isobar curving through southern Texas is marked 29.8, a difference of 1.1 inch in the air pressure between Montana and Texas. The red isothermal line in Montana is marked 30 degrees below zero, while the isotherm on the Texas coast indicates a temperature of 50 degrees.

The people of the Gulf states, with a morning temperature of 40 to 50 degrees, knew nothing of the great volume of extremely cold air to the northwest of them; but from the distribution of air pressure shown by chart IV the forecaster anticipated that the cold air of the northwestern states, on account of its great weight, would be forced southward to the Gulf and eastward to the Atlantic Ocean, or, more accurately speaking, that the conditions causing the cold in the northwest would drift southward and eastward. He therefore issued the proper warning to the threatened districts.

Now turn to chart V of the following morning, and it will be seen that the cold wave has covered the entire Mississippi Valley. The 10-degree isothermal line has been forced southward almost to Galveston, where the temperature the preceding morning was 50 degrees.

The low shown on the preceding chart as being central in southern Texas has moved northeastward to Alabama and on chart V appears as a fully developed storm. The difference in pressure between the central isobar of the low and the central isobar of the high is now 1.4 inches.

The low is lower and the high is higher—conditions that argue ill for the coast line toward which the low is moving. Next look at the arrows at the coast stations from Key West, Florida, to Eastport, Maine; they are found to have short bars at one end, which indicate that every port, large and small, between these two places is flying danger signals, and that every promontory or island along this vast stretch of seashore will exhibit the warning lights of the Weather Bureau as soon as night falls.

Twenty-five years ago mariners depended on their own weather lore to warn them of coming storms; then, although the number of ships plying the seas was much less than it is now, every severe storm that swept across them left

death and destruction in its wake, and for days afterward the dead were cast up by the subsiding waters and the shores were lined with wreckage. Happily this is not now the case. The angry waters and the howling winds vent their fury the one upon the other, while the great mass of shipping, so long the prey of the winds and the waves, rides safely at anchor in convenient harbors.

The large figures in the four quarters of the low again strikingly illustrate how great may be the difference in temperature, under cyclonic influence, between regions separated by but short distances. It is certain that as the low or cyclonic whirl moves toward the northeast, along the track usually followed by storms in this locality, the cold of the northwest quadrant, by the action of the horizontally whirling disk of air that constitutes the low, will be driven southeastward toward Florida, lowering the temperature in the orange groves to below the freezing point.

Chart VI shows that the center of the cyclone has moved during the preceding 24 hours northeast to the coast of New Jersey, with greatly increased energy, the barometer at the center showing the abnormally low reading of 28.7 inches. Cold northwest winds, as shown by the arrows, are now blowing systematically from the high-pressure area of the northwestern states southeast to Florida and the South Atlantic coast. The red isotherm of 30 degrees passes through the northern part of Florida, where, on the day before, the temperature was over 50 degrees. The cyclonic gyration of this storm extends 1,000 miles inland and probably to an equal distance out to sea. Heavy snow or rain has fallen throughout the area under its influence, seriously impeding railroad travel, and a gale of hurricane force has prevailed on the coast ; but when, on the day preceding, the storm was central in Alabama all these conditions were foreseen and the necessary warnings issued.

Chart VII shows the conditions 24 hours later. The storm center, as shown by the line of arrows, has been three days in passing from southern Texas to the mouth of the St Lawrence. The temperature has fallen still lower on the Atlantic coast and in Florida as the result of uninterrupted northwest winds, and no material rise in temperature can occur until the high pressure of the northwest is replaced by a low pressure, and convectional currents are drawn toward the northwest instead of being forced southward from that region.

When the charts indicate the formation of a large volume of dense, cold air in the northwest, as shown by the barometer readings, the skilled forecaster is on the alert. He calls for special observations every few hours from the stations within and directly in advance of the cold area, and as soon as he becomes convinced that the cold wave will sweep across the country with its attendant damage to property, destruction to animal life, and discomfort to humanity, the well-arranged system of disseminating warnings is brought into action, and by telegraph, telephone, flags, bulletins, maps, and other agencies the people in every city, town, and hamlet, and even in farming settlements, are notified of the advancing cold 12, 24, or even 36 hours before it reaches them ; and it is safe to say that $10,000,000 is a low estimate to make of the value of the perishable property that is protected in the United States as the result of the warnings that are distributed by the government in advance of the coming of only one of several severe cold waves that occur each winter.

In the late spring and early fall the highs or anti-cyclones, while possessing less energy than in the winter, may at times bring down to the earth such unseasonably cold air as to cause injurious or destructive frosts, the frosts being caused not necessarily by the cool air of the high, but by the clearness of

the air, which allows a free escape of heat from the earth by radiation at night. As in the case of cold waves, warnings are widely distributed in advance of the high that may cause frosts, with great profit to the growers of tender fruits and vegetables.

In a general way the degree of cold in a cold wave, or rather the departure of the temperature from the normal of the season, will be proportional to the height of the barometer, and a necessary concomitant of a cold wave is an area of low pressure immediately in advance of the high pressure, the upward movement in one increasing the downward motion of the other; and the greater the difference in the barometer between the two the greater the velocity with which the air will gyrate about and into the low, and the greater the downward and outward movement of the air in the high, and the more intense the cold. It therefore follows that a high that is not preceded by an active low will have a less degree of cold for a given pressure, and that the extent and intensity of cold waves depends considerably on the form and the characteristics of the preceding low and its location; if north of the center of the country the cold that follows will not reach the Gulf states in severe form, if at all; but if a low of considerable energy forms in the region of Texas and moves northeastward to the Atlantic coast, as nearly all lows do that originate in this region, and a high of equal intensity develops at the same time over the northern plateau of the Rocky Mountains, the latter will be drawn far to the south as the former moves out of the way toward the east, and cold northwest winds, driven by the high and attracted by the low, flow into the Gulf of Mexico itself, even reaching the islands of the West Indies.

It would be impossible for a cold wave to come upon the Pacific Coast states with the highs that drift in from the ocean, because of the warming effect of the water upon the air to considerable elevations; but frosts and cold waves visit the interior valleys of California and other coast states and reach almost to the ocean's edge. They are due to highs that move southward and then eastward along the plateau. The highs may be moving eastward very slowly, but the diameter of the areas covered by them may increase so rapidly that some cold air is pushed over the mountain tops and flows from the northeast into the interior valleys of the coast states.

The U. S. Weather Bureau has adopted certain arbitrary thermal limits to determine what constitutes a cold wave. Both the extent of the fall of temperature and the degree of cold that must be reached vary for season and place. For example, in December, January, and February a cold wave in the northern Rocky Mountain region occurs when the temperature falls 20 degrees in 24 hours and reaches a minimum of zero or lower; in Tennessee a fall of 20 degrees, and to 20 degrees or lower is required, while along the Gulf coast a fall of but 16 degrees and to 32 degrees constitutes a cold wave. The fall in temperature is reckoned from any given hour of one day to the same hour of the next day or from the minimum of one day to the minimum of the next.

The area and the intensity of cold waves depend upon the size of continents and their distance from the tropics. The interior of North America and of Siberia have geographic conditions that cause the most severe cold waves of any parts of the world. If the elevation of the Rocky Mountain plateau in North America were one-half of what it is and if the mountain chains were leveled away, or even trended to the east and west instead of north and south, the vaporous atmosphere of the Pacific, which extends upward but a very short distance and which decreases in density rapidly with elevation, be-

cause of the inability of water to exist in the vaporous form in considerable quantities except under the action of the comparatively high temperatures of the thin stratum near the earth, would flow far into the interior of the continent, and by absorbing the heat of the sun during the day and restricting radiation from the earth at night markedly decrease the severity of cold waves and other changes in temperature. Hence it is seen that the height of mountain systems and their trend relative to large bodies of water and to the prevailing direction of winds are important factors in the causing of cold waves.

As stated before, the air has a downward movement in the anti-cyclone, which may be so feeble as to cause only a slight change in temperature at the earth, or it may be active enough to lower the temperature down to the frost line in spring or fall, or even have such energy as to cause a cold wave in winter. In the latter case the air possesses such intense cold at the elevation from which it is drawn that, notwithstanding the fact that it gains heat by compression at the rate of about 1 degree for each 200 feet of descent, it is still far below normal temperature when it reaches the earth. Its initial temperature is so low that it can contain only a minute portion of water vapor ; it therefore evaporates all fog or cloud as it gains in temperature during its fall, and by flowing away laterally along the earth it drives away the more humid air of the lower strata. The downward motion thus introduces conditions of clearness and deficiency of water vapor that promotes free radiation and the loss of much of the heat dynamically gained as well as that given off by the earth to the air. It therefore seems that departures from the normal temperature of a time and place are the result of *the motions of the air* below the height of 10 miles. Ascending and descending currents cease before this altitude is reached, and it is probable that the temperature of this region changes but little from season to season and from year to year, although short-period observations with the bolometer, which registers changes in the amount of heat that falls upon the outer limits of the air, indicate that in time it possibly may be necessary to modify this opinion.

Few people realize that the cold wave has an important therapeutic value. It scatters and diffuses the carbonic-acid gas exhaled by animal life and the fetid gas emanating from decaying organic matter. Its dense air not only gives more oxygen with each inspiration of the lungs, but the high electrification that always accompanies it invigorates man and all other animal life. The cold north wind, if it be dry, as it usually is, brings physical energy and mental buoyancy in its pure but boisterous breath.

HURRICANES

Most of the storms that gain such a velocity of gyration as to consitute hurricanes originate in the tropics and move northwestward to latitude 26 degrees to 32 degrees, where they recurve and move toward the northeast. These are the most severe of all the storms that visit the North American continent. The West Indies and the Philippines are the regions wherein these forceful storms originate in the greatest numbers, and the commerce of all nations has profited largely by the spirit that has prompted the United States to establish, since 1898, a complete system of cable-reporting meteorological stations in both of these sections, which enables a central station to keep mariners advised of danger.

At times hurricanes remain several days in the Gulf of Mexico or off our South Atlantic coast, and the only indication we have of their proximity is a strong suction drawing the air briskly over some of our coast stations toward the center of the storm. Again, a

heavy ocean swell may be caused by the friction of the rapidly gyrating air on the surface of the water, and when the hurricane has a slow progressive movement, as it usually has south of latitude 30 degrees, this swell may be propagated outward from the center of the storm faster than the storm is moving and reach the coast several hours before either the barometer or the wind movement gives any indication of the coming storm.

The tracks of West Indian hurricanes are usually in the form of parabolas. These storms come from the southeast, but on reaching the latitude of our Gulf coast they, as a rule, recurve to the northeast and pass along our coast line or near to it.

Chart VIII shows a West Indian hurricane just making its advent into Florida. The effect of the storm is felt as far north as Wilmington, where the wind is being drawn from the northeast at the rate of 24 miles per hour, and danger warnings, as indicated by the bars on the arrows, are being displayed as far north as Norfolk, both at the regular observation stations of the Weather Bureau and at all the numerous large and small harbors of the South Atlantic coast. The winds at Savannah and Jacksonville are moving from the northeast and north, respectively, at 20 miles per hour, which is four miles less than at Wilmington, farther away from the storm center. This apparent inconsistency may be due to the low and restricted exposure of the instruments at the nearer stations, but not necessarily so, as the winds never blow into or around a storm at velocities that are evenly and consistently in accord with the pressure gradients, but rather in the form of rising and falling gusts.

Observe that there are no warnings flying at Key West; this is because the storm center is moving away, and the wind cannot therefore reach any higher velocity than it now has, and must steadily decline.

In studying the winds about this storm center, or rather about such part of it as projects over the land, recall the story about Franklin's northeast storm. It will be seen how it is possible for storms to progress against the wind. In thunder-storms this rule does not hold. They cover but an infinitesimal area in comparison with a cyclone, and there is a horizontal rolling of the atmosphere, caused by cold and heavy air from above breaking through into a lighter superheated stratum next the earth. This rolling motion throws forward the cool air in the direction in which the cloud is moving.

Chart IX shows a slight aberration in the northeast course of the storm, which places the center inland, so that the whole cyclone can be charted. From eastern Florida the usual course is northeast over the ocean instead of up through Georgia and the Carolinas. What caused this storm to depart from the usual course? The reason can be easily found, and it is important that one should find it. The high over New England and the contiguous ocean had a tendency to crowd the storm inland and cause it to seek the route of least resistance, and the low over the Lake region attracted it. That is the reason; it will be made plainer when we come to consider the translation of storms.

The storm has been destructive to marine property, the wind at Savannah reaching 72 miles per hour, and 48 miles at Jacksonville, and warnings are now displayed at all ports northward to New England, as the hurricane will move northward between the two highs along the lines of least pressure. Chart X shows that it traveled from northern Georgia to central New York during the next 24 hours. The storm center passing northward over the land instead of the water, the hurricane winds on the water were onshore—a condition that strewed the coast with the wreckage of many vessels that were unable to see the warning signals in time to seek har-

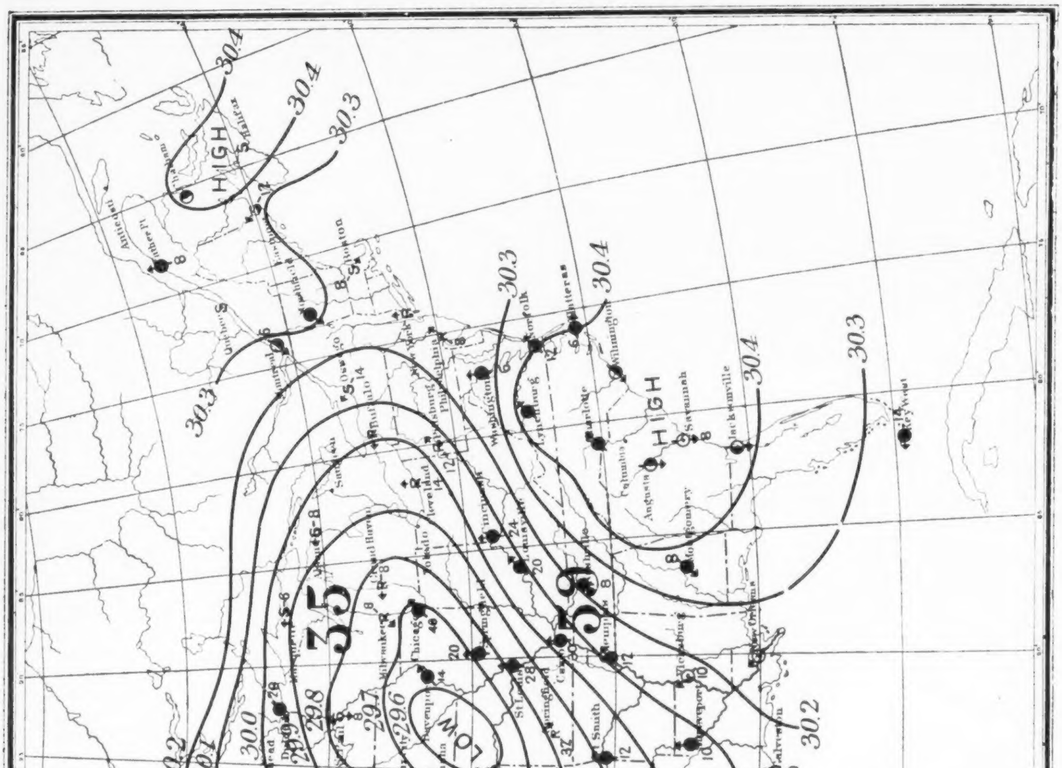


CHART I.—Winter Storm, December 15, 1893, 8 A. M.

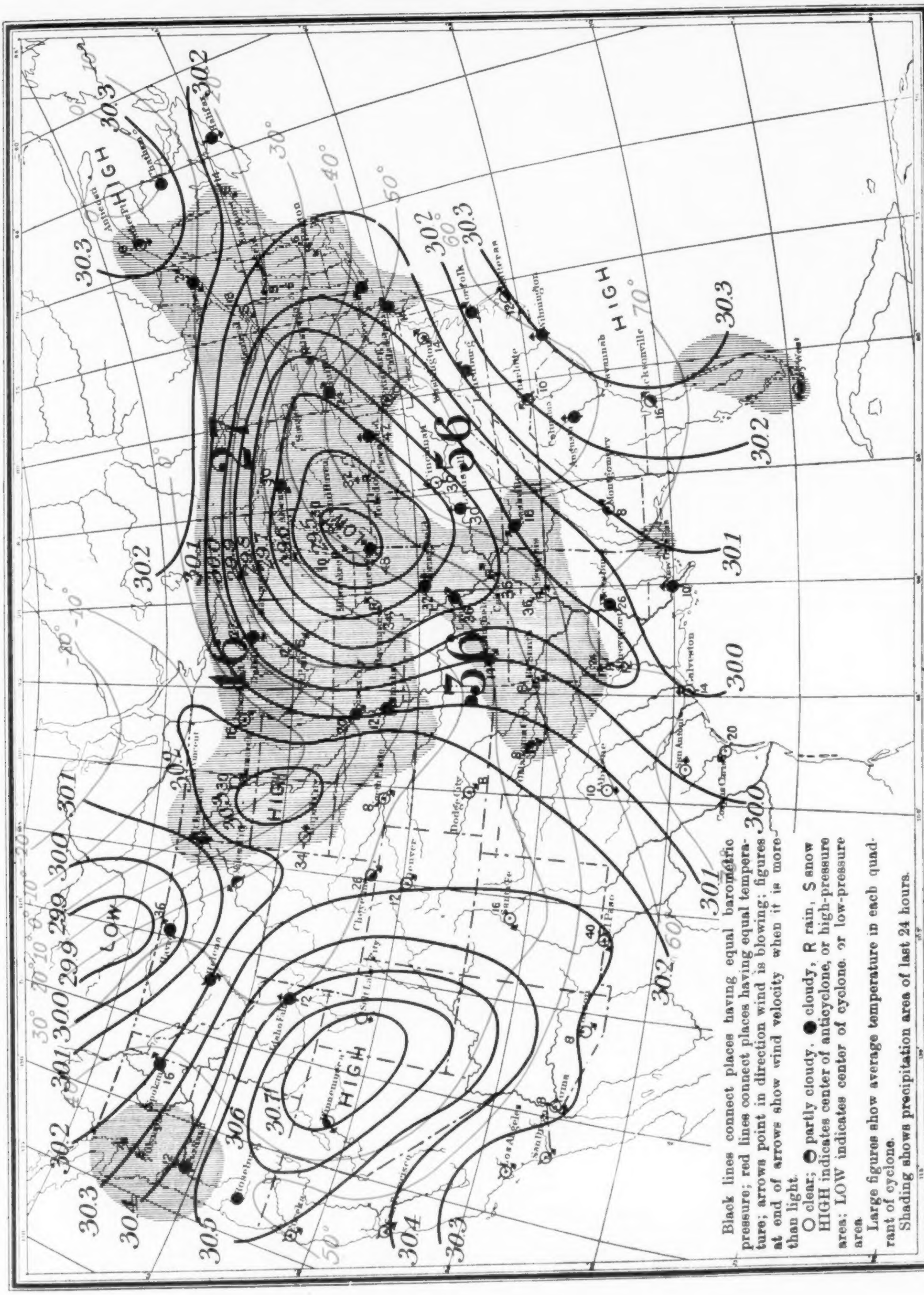
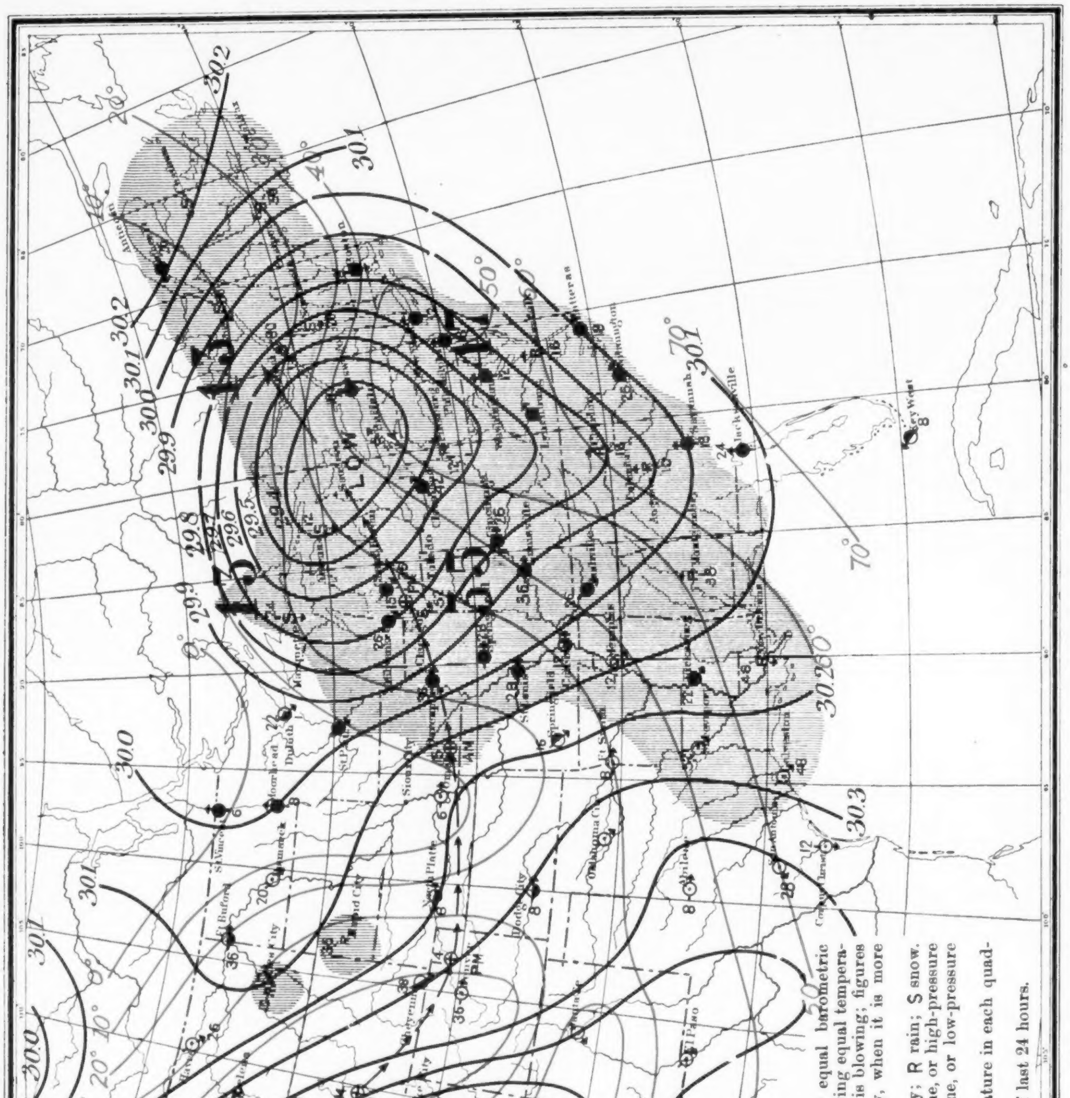


CHART II.—Winter Storm, December 15, 1893, 8 P. M.



Black lines connect places having equal barometric pressure; red lines connect places having equal temperature; arrows point in direction wind is blowing; figures at end of arrows show wind velocity, when it is more than light.

○ clear; ◐ partly cloudy; ● cloudy; R rain; S snow.

HIGH indicates center of anticyclone, or high-pressure area; LOW indicates center of cyclone, or low-pressure area.

Large figures show average temperature in each quadrant of cyclone.

Shading shows precipitation area of last 24 hours.

CHART III.—Winter Storm, December 16, 1893, 8 A. M.

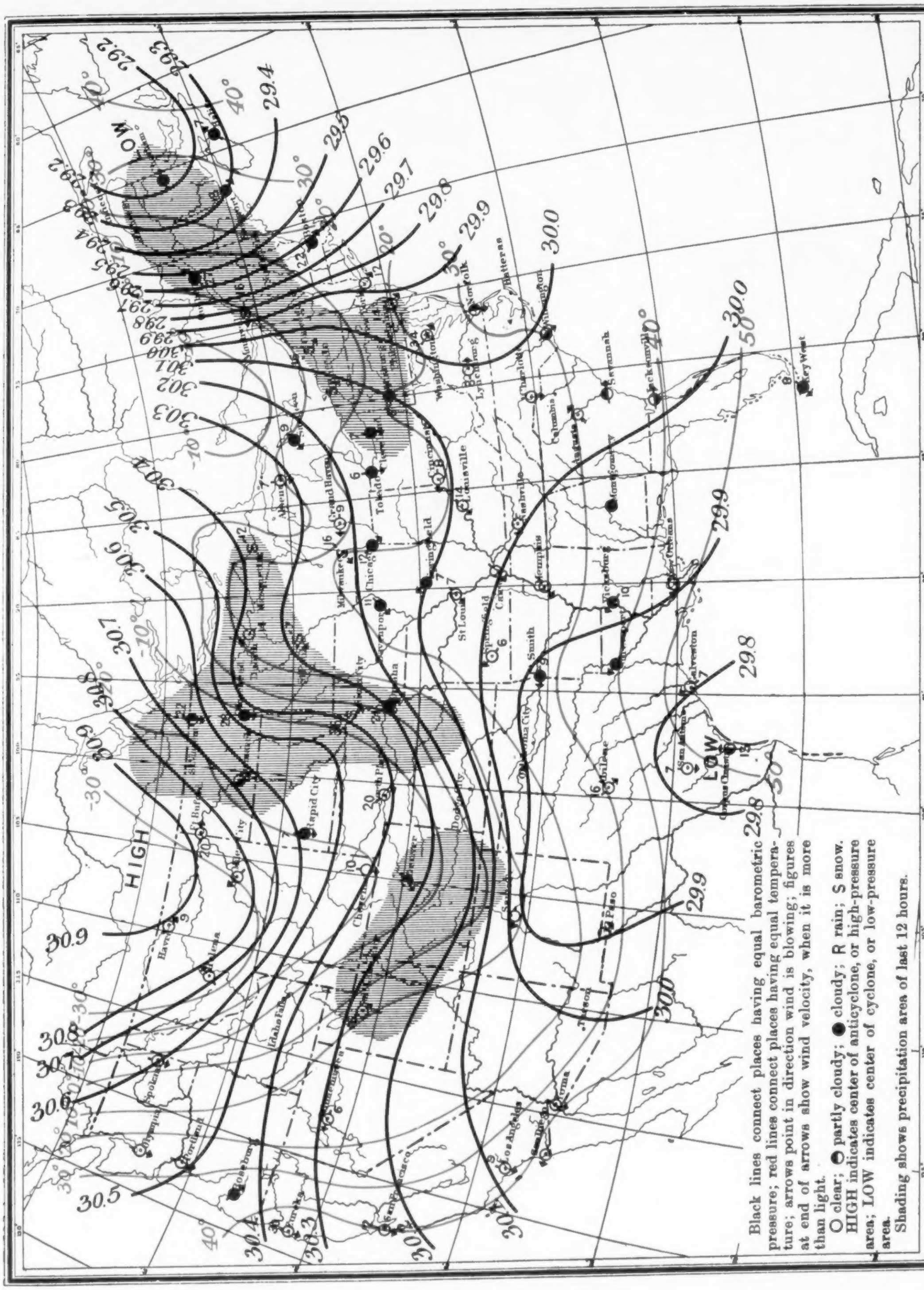


CHART IV.—Cold Wave, January 7, 1886, 7 A.M.

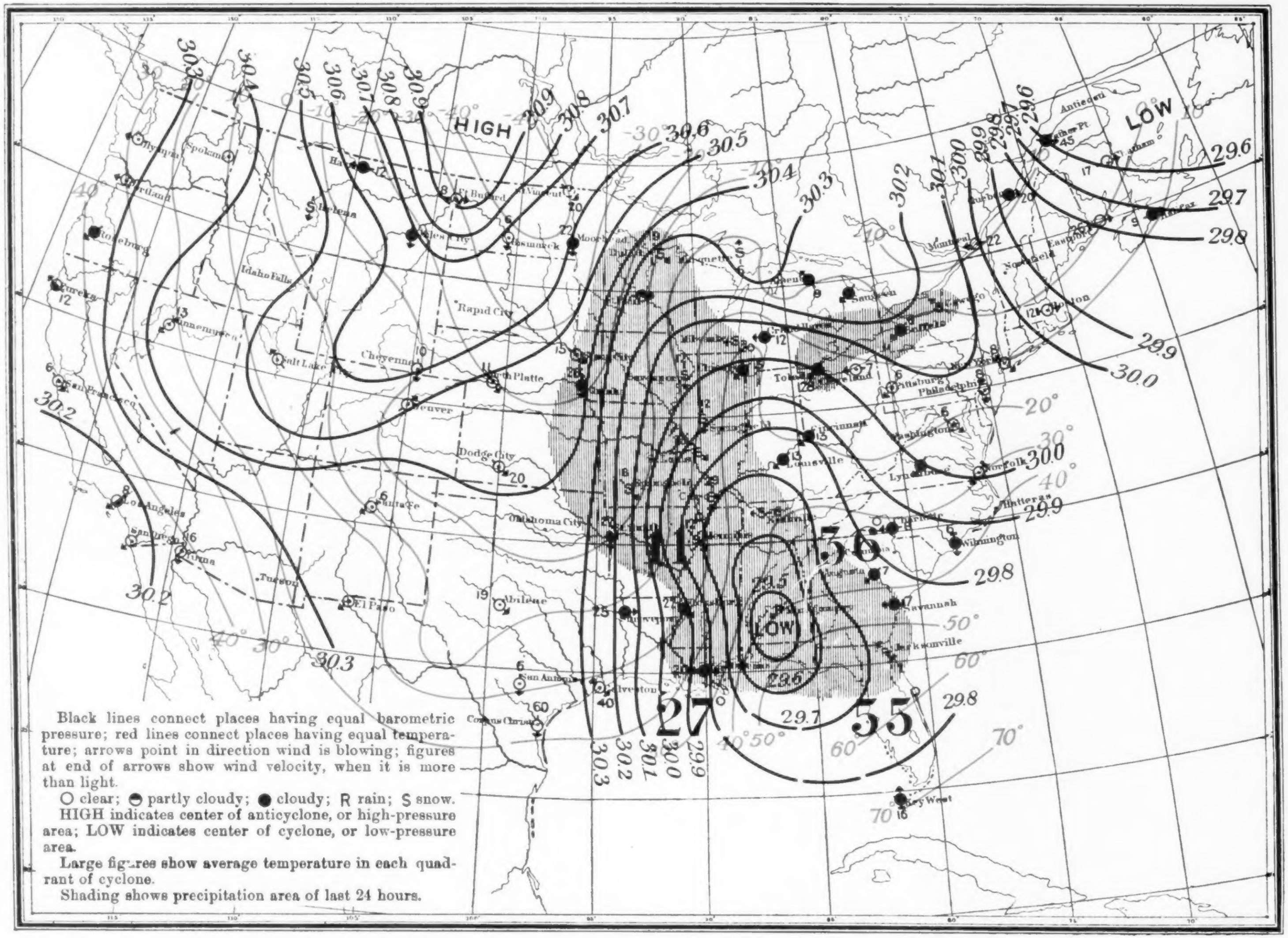


CHART V.—Cold Wave, January 8, 1886, 7 A. M.

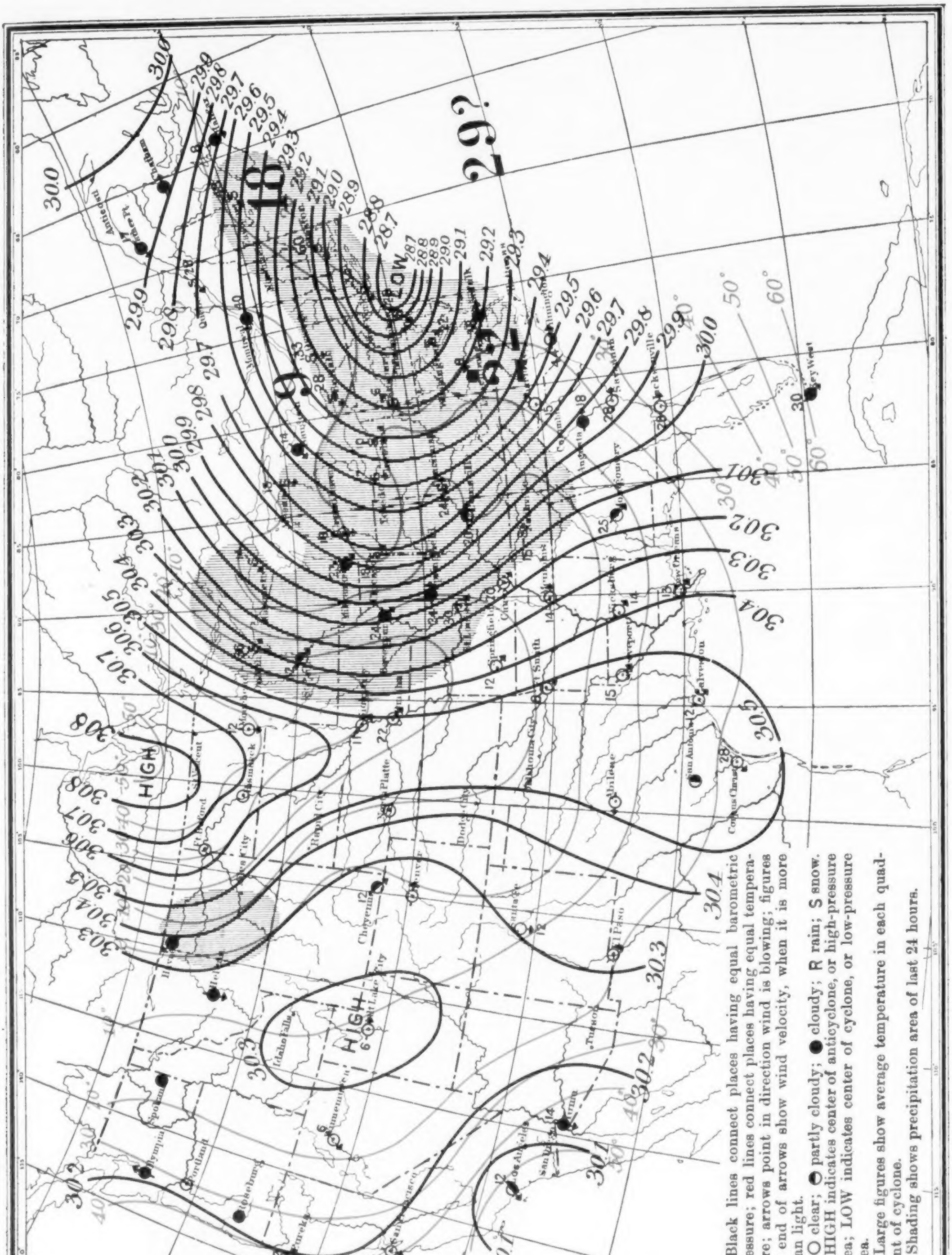
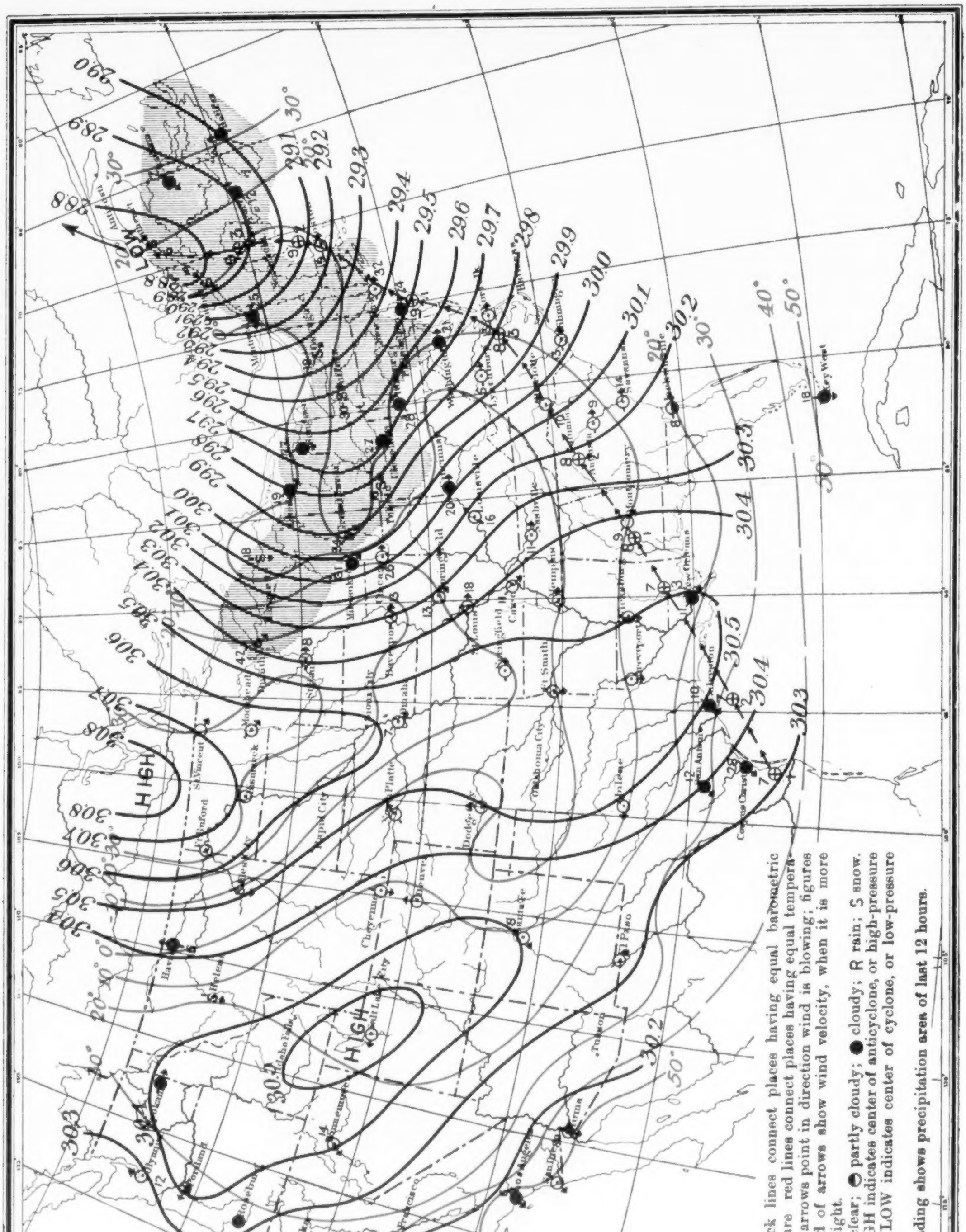


CHART VI.—Cold Wave, January 9, 1886, 7 A. M.



Black lines connect places having equal barometric pressure; red lines connect places having equal temperature; arrows point in direction wind is blowing; figures at end of arrows show wind velocity, when it is more than light.

O clear; ◐ partly cloudy; ● cloudy; R rain; S snow. HIGH indicates center of anticyclone, or high-pressure area; LOW indicates center of cyclone, or low-pressure area.

Shading shows precipitation area of last 12 hours.

CHART VII.—Cold Wave, January 10, 1886, 7 A. M.

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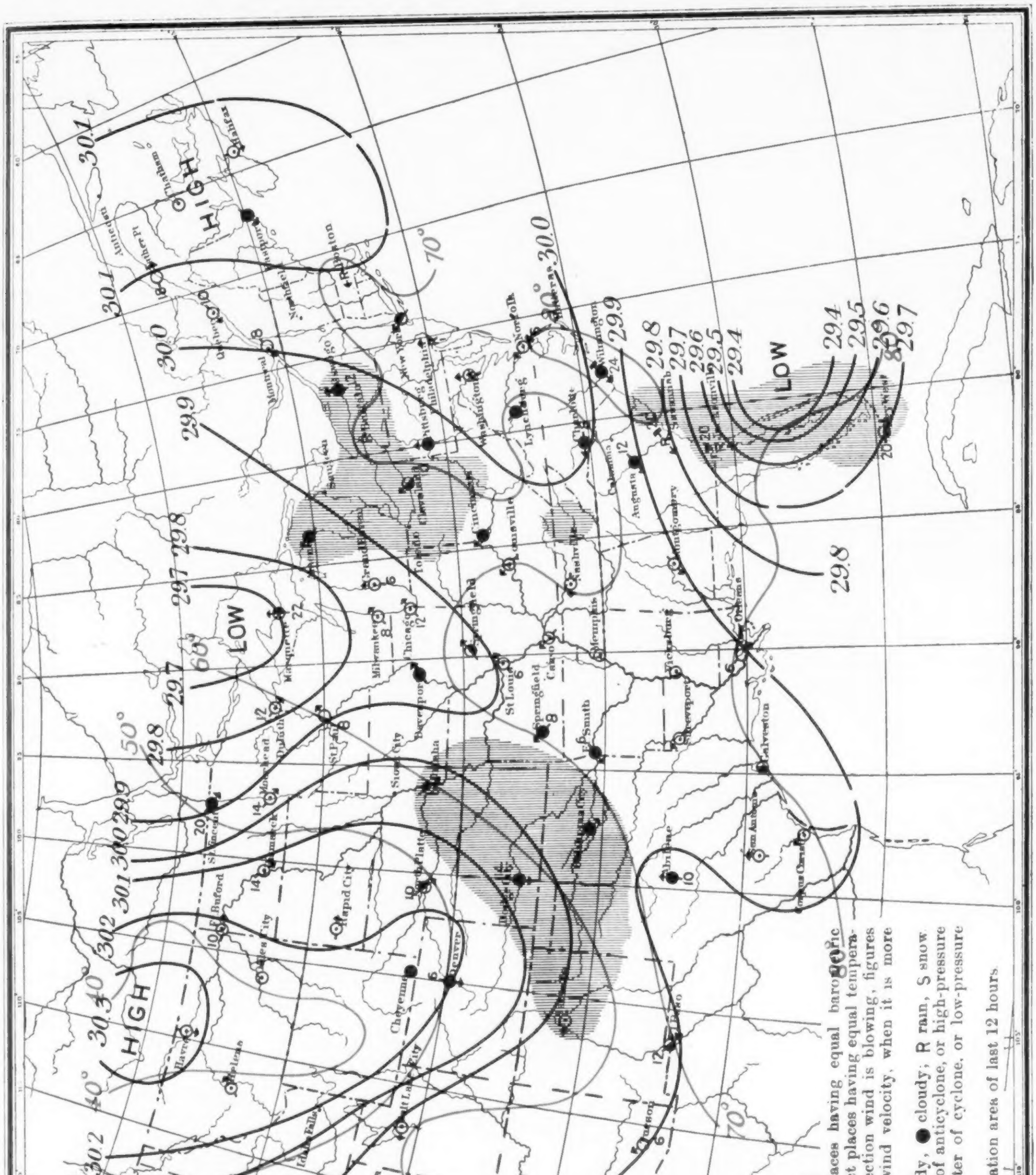

CHART VIII.—West Indian Hurricane, August 27, 1893, 8 A. M.

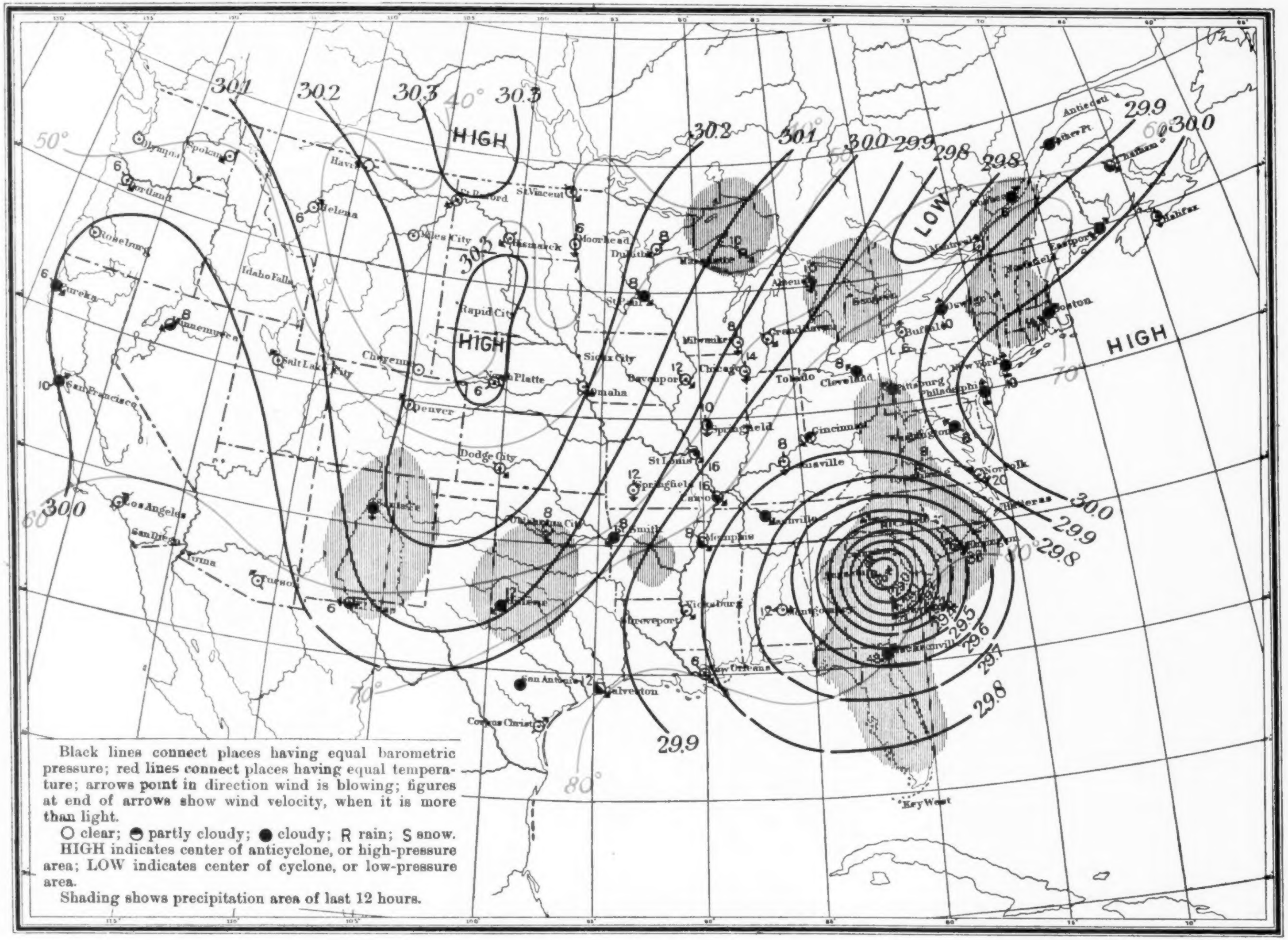

CHART IX.—West Indian Hurricane, August 28, 1893, 8 A. M.

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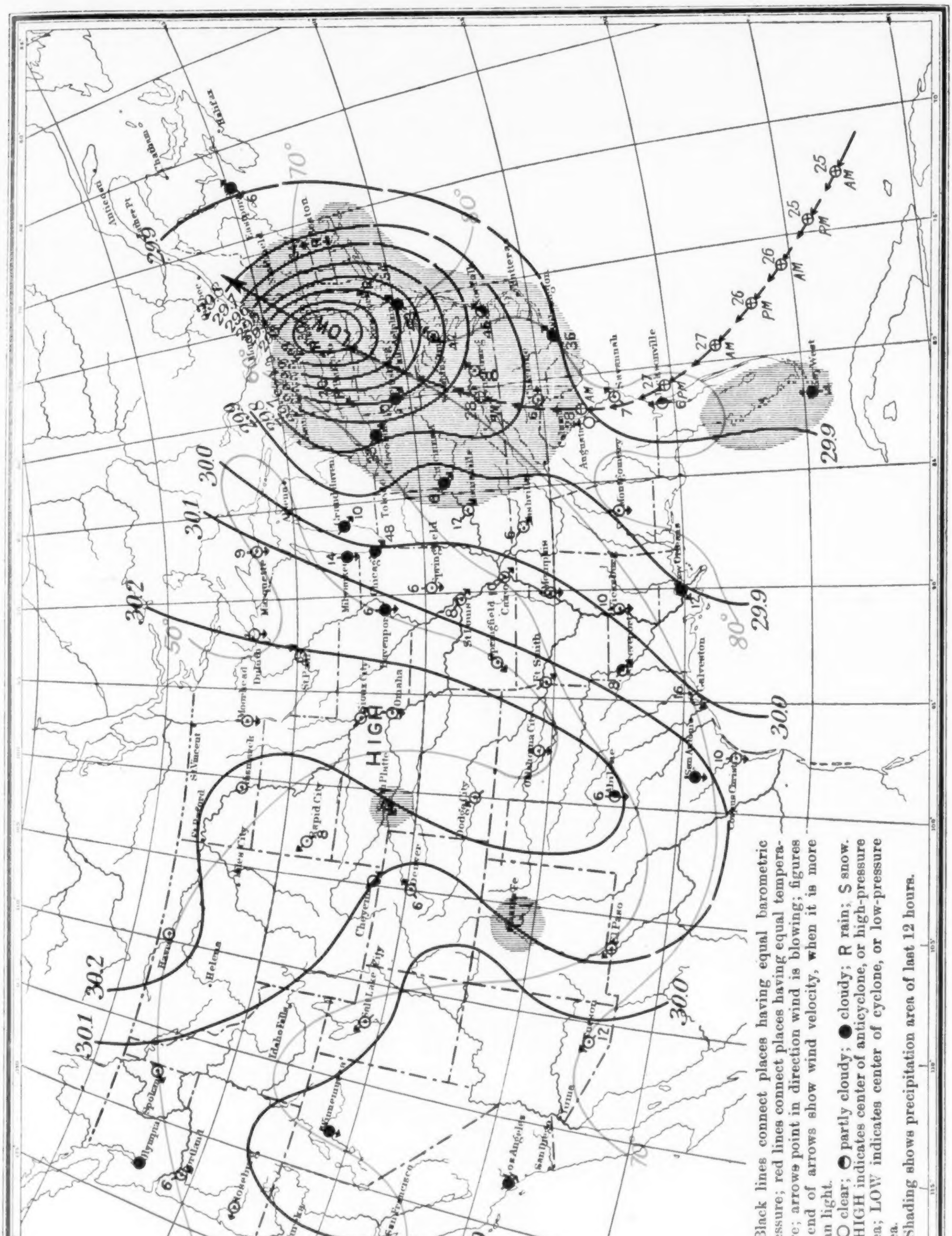


CHART X.—West Indian Hurricane, August 29, 1893, 8 A. M.

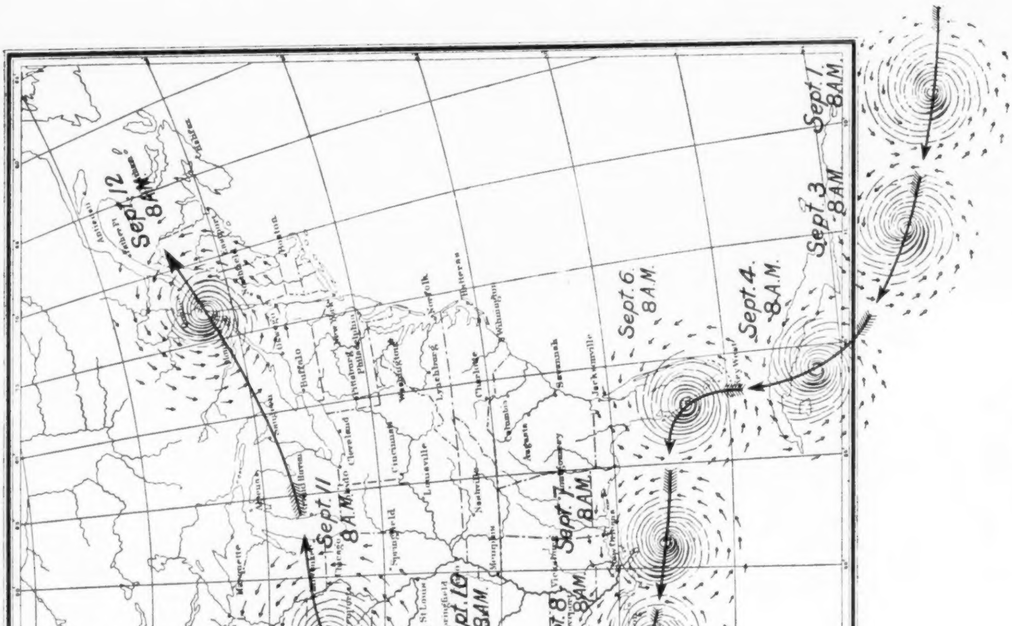


CHART XI.—The Galveston Hurricane, 1900

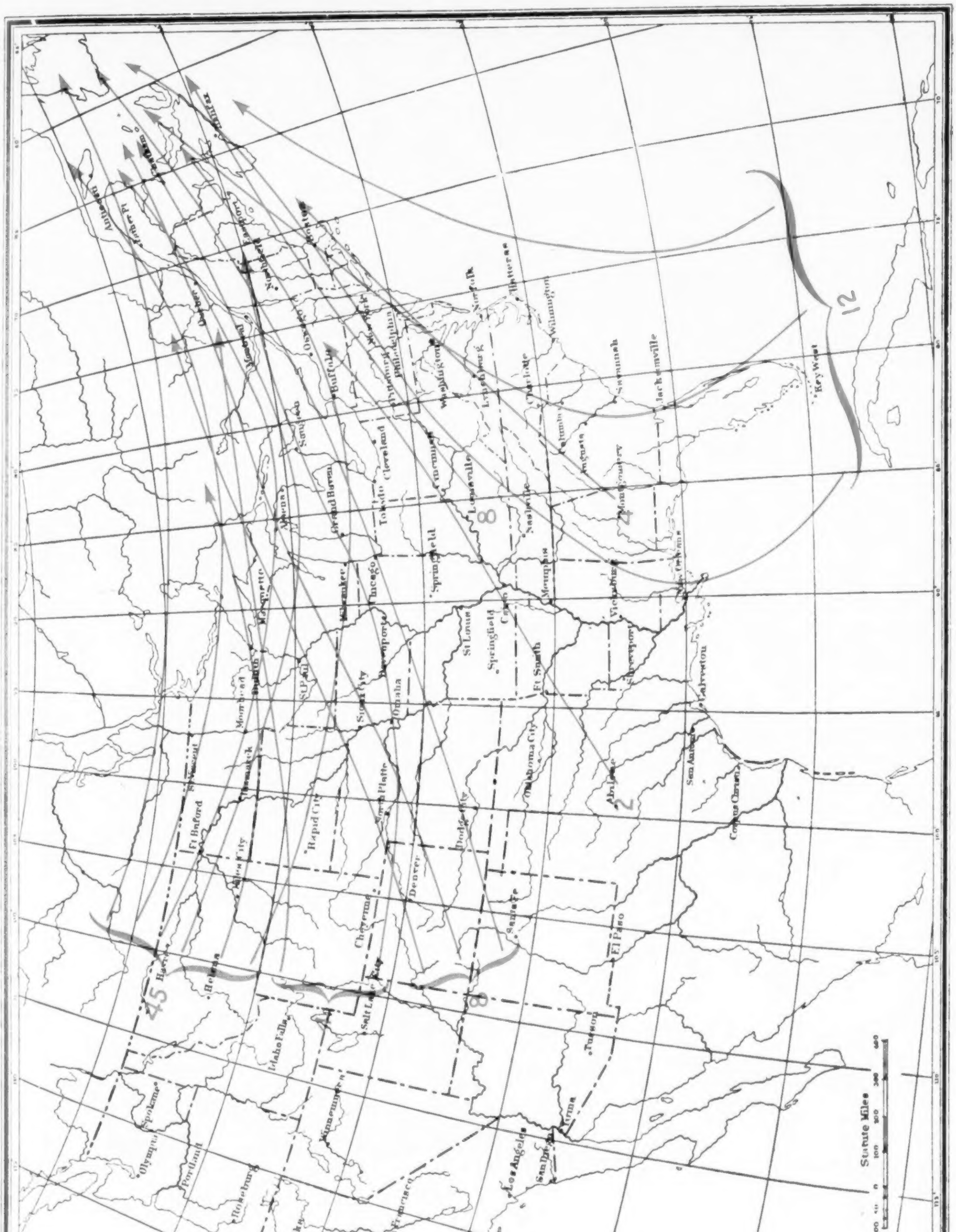


CHART XII.—Storm Tracks for August

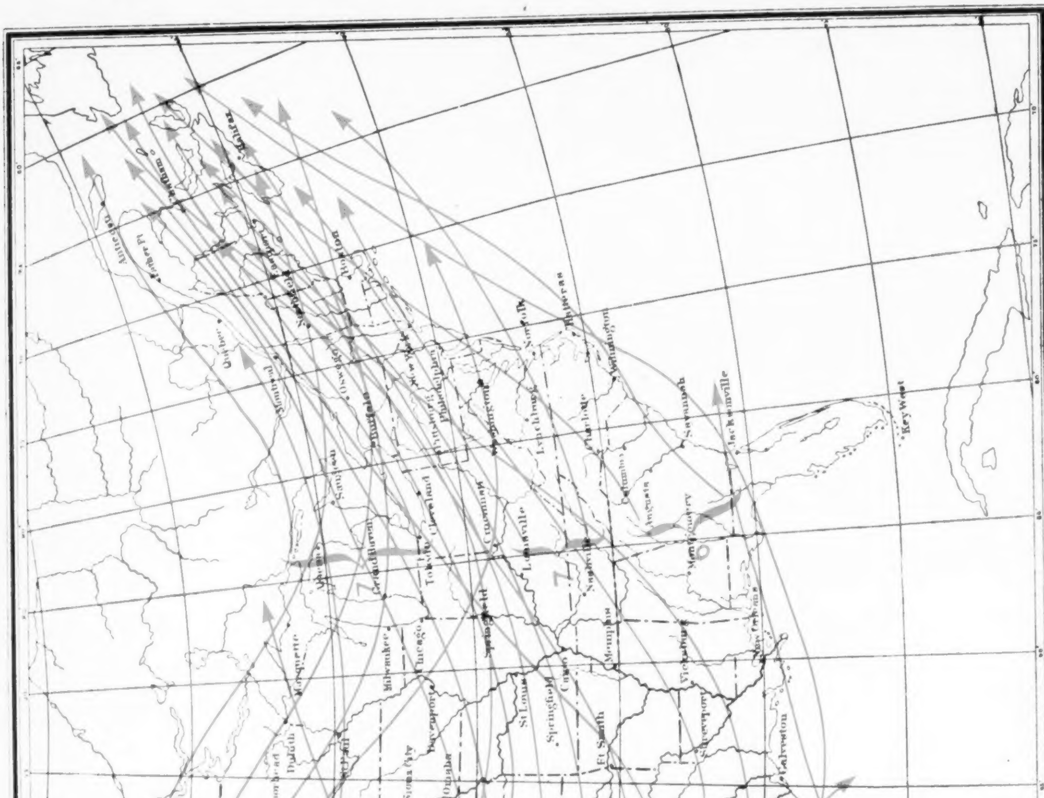


CHART XIII.—Storm Tracks for February

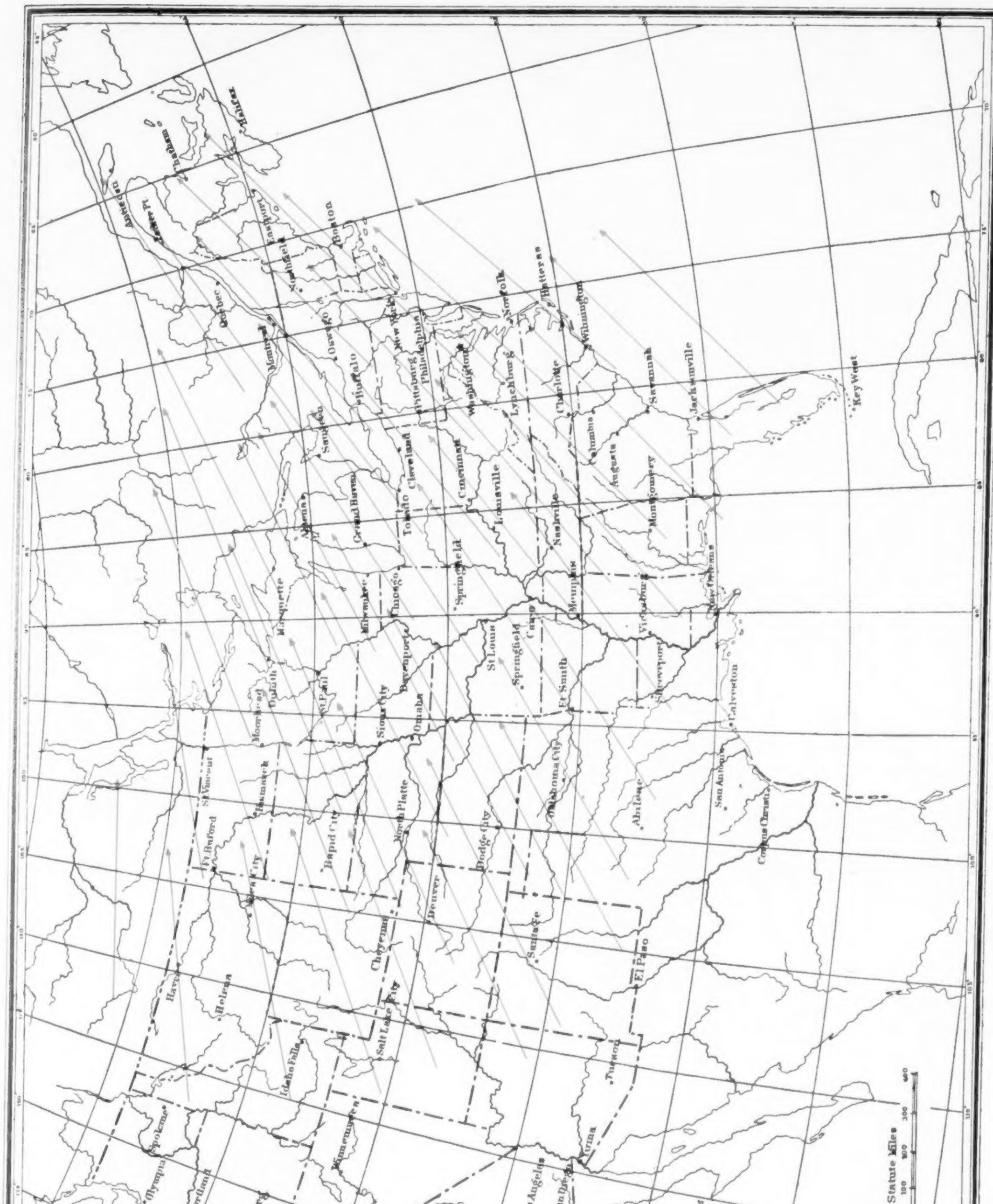


CHART XVII.—Normal Storm Tracts for May

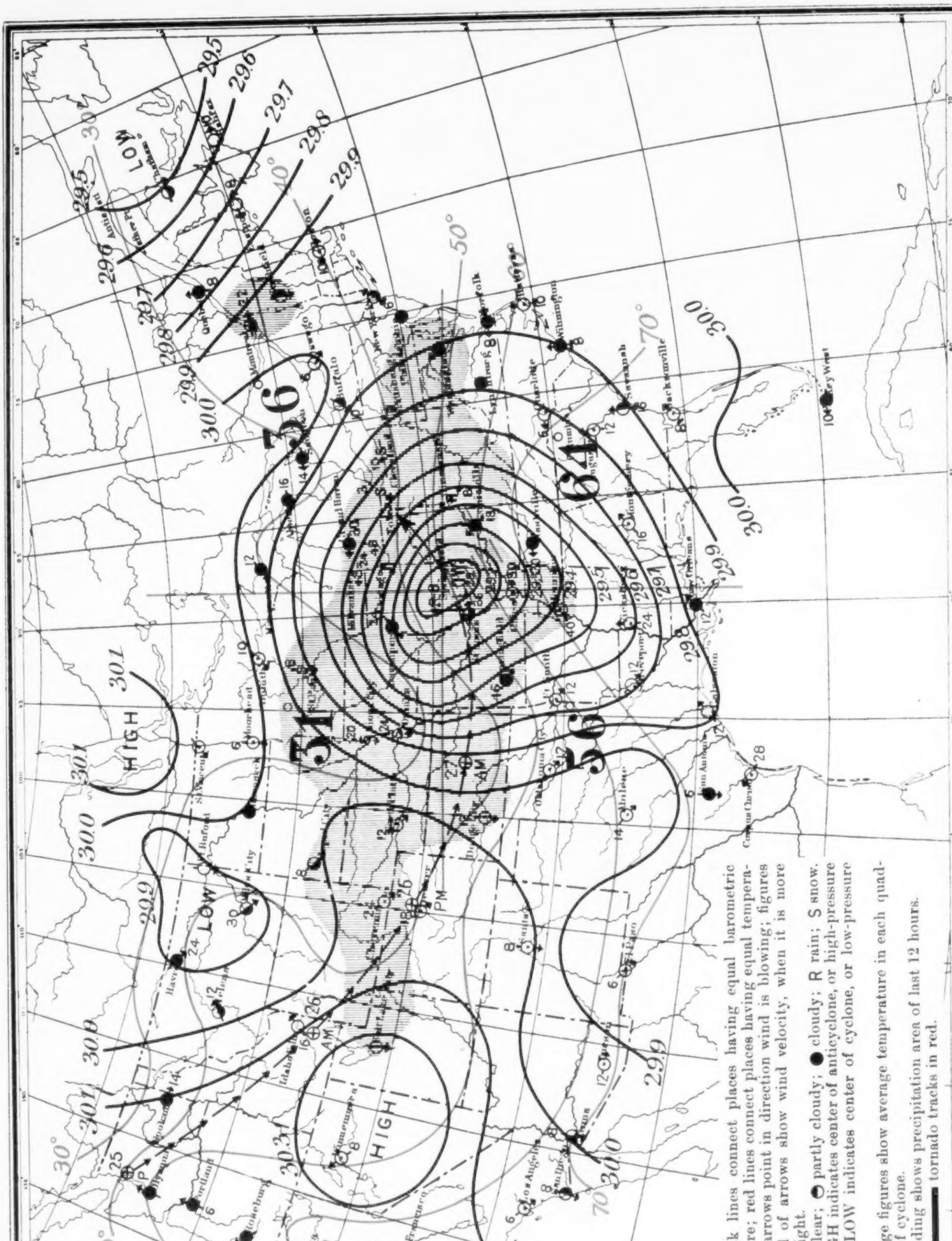


CHART XVIII.—Tornado at Louisville, Ky., March 27, 1890. Weather Map 8 P. M. of that date

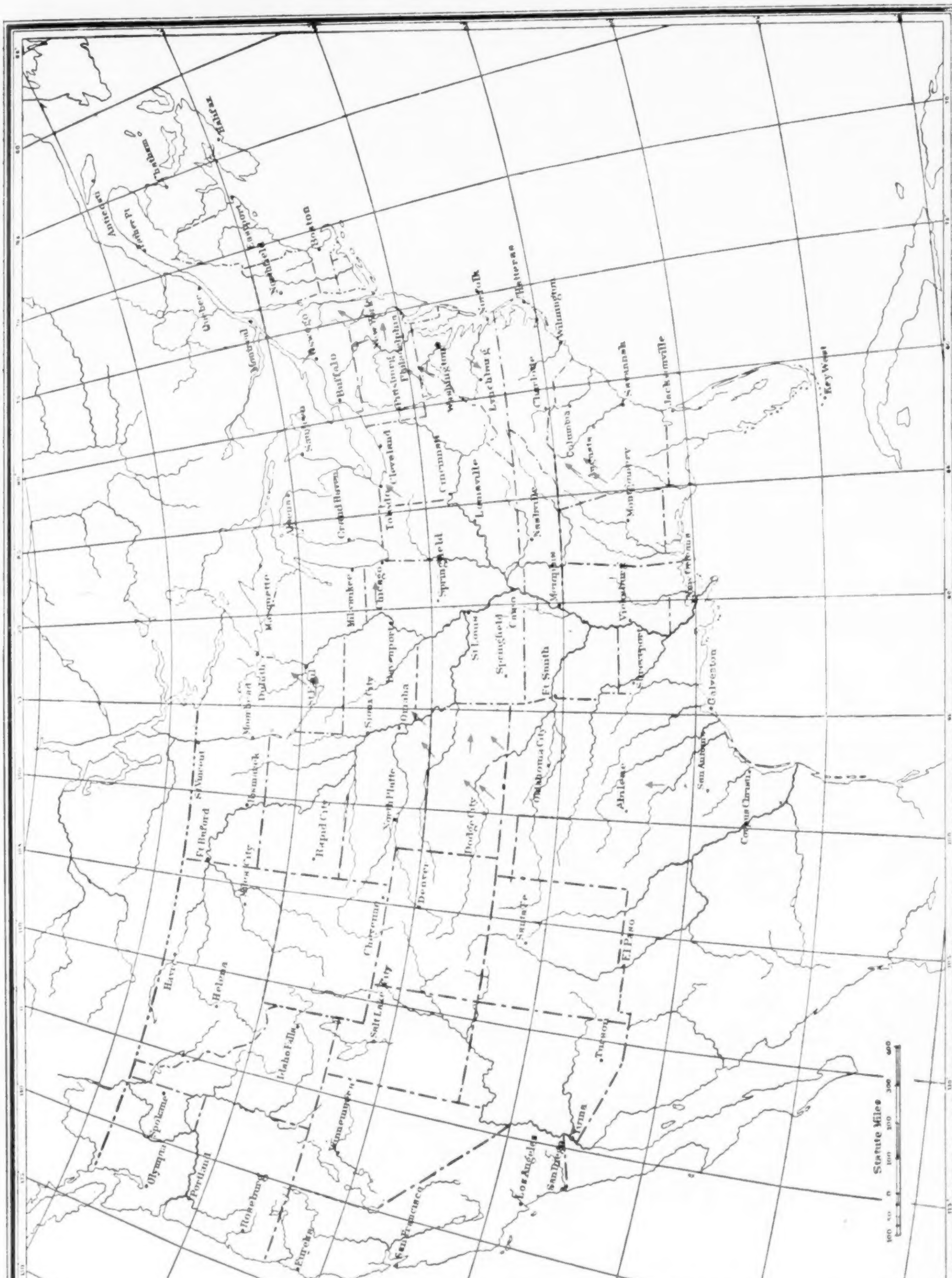


CHART XIX.—Tornadoes of 1889—a year of small frequency

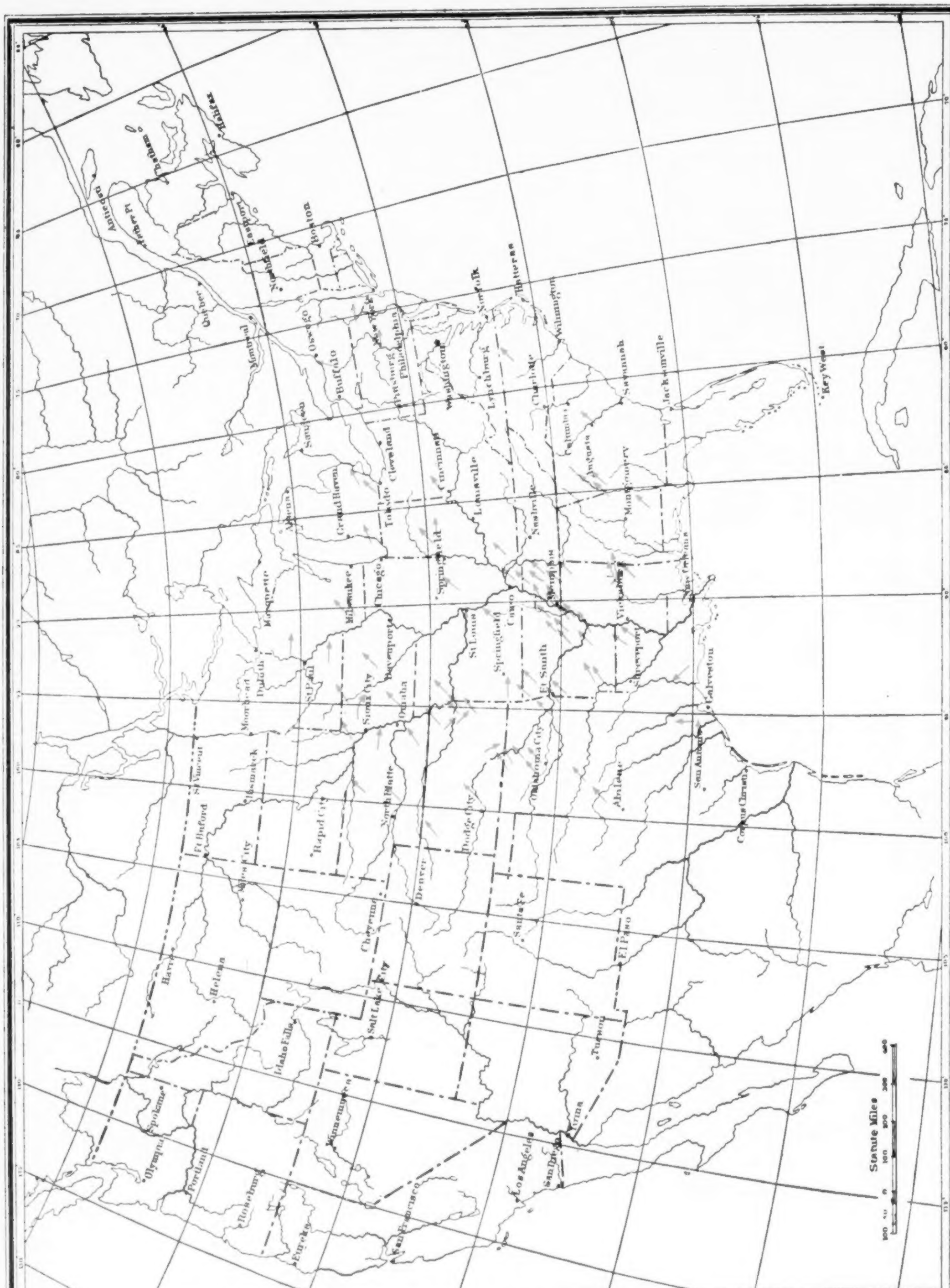


CHART XX.—Tornadoes of 1893—a year of great frequency

bors of safety. It is pertinent here to ask the student of weather forecasting what would have been the direction of the wind and its effect on the coast line if the storm had followed the usual course and passed northeastward with its center over the water instead of over the land. By this time the reader should be able to answer: The winds would have been from the west and much less harmful to mariners, because the surface water would have been driven seaward instead of being banked up in boisterous billows upon the shore, and ships would have scudded out to ocean before the gale instead of being broken up on the reefs.

West Indian hurricanes are cyclonic in character, but on account of the fact that the diameter of the whirling eddy is much less and the velocity of rotation much greater than in the average cyclone, it is customary to designate them as hurricanes. In other words, the hurricane is a cyclone of small area, but of powerful vortical action, and consequently of great destructive force.

Chart XI shows the track of the Galveston storm. The spirals are not true pictures of the storm; neither do they represent pressure lines, as other charts have done. They are used to illustrate more clearly than can be done in any other way the eddy-like motion of a cyclone and at the same time give the location of the hurricane on various dates.

In explaining the hurricane of October 27, 1903 (chart VIII), it was stated that the storm was deflected a little from its normal course by an anti-cyclone that rested over the ocean. A similar distribution of air pressure occurred on September 6, 1900, when the hurricane was over Florida, except that the anticyclone covered the whole region from the Mississippi River eastward to Bermuda and southward to the Gulf. The storm was therefore forced to travel westward around the high to the Texas coast before it could turn to the northeast. It was first detected in the Caribbean Sea. It then moved at the rate of only about eight miles an hour. It increased its speed between Florida and the Texas coast to about 12 miles. It did not become destructive until after it passed into the Gulf. Then its velocity of gyration became so great that the water was beaten into a fury and great swells were propagated outward in advance of the storm, some of which reached Galveston 16 hours before the hurricane. As the storm passed over the latter city the anemometer registered 100 miles per hour and then broke into pieces. This was probably nearly the highest velocity reached, as it occurred at about the time of lowest barometer, which was 28.48 inches. As the storm moved toward the Lakes its rate of translation increased to about 60 miles per hour, but its destructive force was much less on the land than on the water, although it produced wind velocities of over 70 miles at several Lake stations, which, by the way, were amply warned of the coming of the storm, as were all Gulf ports.

Between July and October, inclusive, there are annually about ten tropical storms that touch some portion of the Atlantic or Gulf coast. On an average, less than one per annum is severely destructive. Most of them are of such a nature that if timely warnings be issued, as they usually are, little loss of life or property occurs. As to the frequency with which these storms visit the Gulf, it may be said that the late Increase A. Lapham, of Wisconsin, carefully prepared a list of severe storms, more than thirty-five years ago, to be used by him as one of the arguments for a government weather service. He showed that from 1800 to 1870 ten hurricanes reached some portion of the Gulf coast with a force so marked as to leave authentic records in the local annals of the region. This is an average of one in each seven

years. This average has been maintained since 1870; but no storm has left such an appalling record as the one of September 8, 1900, known as the Galveston hurricane, and it is not probable that we shall again see its counterpart on the Texas coast in centuries.

It is a meteorological coincidence that the West Indies bear the same storm relation to the United States that the Philippines do to China and Japan. With the new possessions of the United States in the Orient it has been possible to establish a storm-warning service that is as valuable to the commerce plying the waters contiguous to the China coast as the service recently organized in the West Indies is to our southern seas.

The hurricanes that occur in the Philippine Islands are called *typhoons*. Like the West Indian storms, they occur mainly during four months of the year—the middle summer and early fall. The late Father Viñes, S. J., a scientist who gave much study to tropical storms, says it must be admitted that cyclones do not form at *any* place within the tropical zones, but that they single out for their formation definite regions within those zones. These regions are always on the southwest periphery of some of the great permanent ocean anti-cyclones. The conditions for the development of cyclones in the tropics are best satisfied when large continents lie to the west, whose coasts trend northward and southward, with extensive seas to the east. Such, at any rate, are the geographic features that concur to form the cyclone regions of the West Indies, of the Philippine Islands, of the China Sea, of the seas of India, of the region east of Africa in the vicinity of the islands of Madagascar, Mauritius, Reunion, Rodriguez, etc.

The cause of all tropical hurricanes may be made clear by confining the explanation to a description of the conditions that permit of the formation of the West Indian storms, which are as follows:

Normally there is a belt of heavy air, of about 10 degrees of latitude in width, lying just north of the tropics, which interposes an almost impassable barrier to the movement of cyclones northward. The region of greatest pressure of this belt is about the middle of the Atlantic Ocean. By August the heat of summer acting on the North American continent has raised the temperature of the air over the land much more than it has that over the water, and the land portion of the high-pressure belt is dispersed, leaving an opening for the escape northward of tropical storms, which form in the ocean on the southwest periphery of the great high-pressure that so persistently remains central over the ocean. From this place of origin the hurricanes are carried northwestward by the general circulation of air outward from and around the big high. This grand summer circulation of the air of the Atlantic Ocean brings the tropical storms nearly or quite to our South Atlantic or Gulf states before they recurve to the north east in pursuing their course around the high. This anti-cyclone of the ocean differs from those that have heretofore been described, in the fact that it quite doggedly holds to nearly the same geographic position. It covers the whole southern ocean, and as the currents of air spirally flow outward, in a direction that agrees with the circulation of the hands of a watch, they frequently break up into small cyclonic whirls of 100 to 300 miles in diameter on the outer rim of the large anti-cyclone, and especially along the southwest quarter of the rim. The air as it runs down through the anti-cyclone feeds the vortices that form at the outer boundaries of the high. The vortex may whirl with the violence of a hurricane, and it usually does; but in its course westward and then eastward it clings to the outer hems of its parent—the anti-cyclone.

The wonderful sweep of the West Indian cyclone is made clear by the

statement that storms of August and September may form southeast of the Windward Islands, cross the Caribbean Sea, recurve in the Gulf of Mexico or near the South Atlantic coast, and pass northeastward over the Atlantic Ocean and be lost in the interior of Europe or Asia. The history of these storms and of all others of the oceans is learned by collecting and charting the daily observations from thousands of moving ships in connection with the observations of island and coast stations.

THE TRANSLATION OF STORMS

The air expands upward to an altitude of 50 miles or more. It is so elastic and its expansion is so rapid as it recedes from the earth that nearly one-half of its mass lies below the three-mile level. Our storms and cold waves are simply great swirls in the lower stratum of probably not more than five miles in thickness, which more than likely are caused by the flowing together, on about the same level, of masses of air of widely different temperatures. An elaborate system of cloud observations, made during recent years, shows that the atmosphere, in the middle latitudes of both hemispheres, flows eastward over these agitations of the lower air without being disturbed by them.

In the temperate zones cyclones and anti-cyclones drift toward the east at the usual rate of 600 miles per day, or about 37 miles per hour in winter and 22 miles per hour in summer; but there is no definite rule on which the forecaster can rely. Sometimes they move at twice this speed, and again at less than half of it, or, what is more embarrassing to the prophet, remain stationary for one or two days and die out. It is safest to assume that the velocity of translation of a storm will be the average of the two immediately preceding it, unless the distribution of air pressure over the continent is markedly different in the several cases. Cyclones and anti-cyclones usually alternate, but not always. At rare intervals a rain-storm or a cold wave may be followed by an atmospheric action similar to itself, with only a narrow neutral area between. The most difficult weather map to interpret and make a forecast from is one that contains several partly developed cyclones and anti-cyclones, each of small area and little force. The most that can be said then is that the weather will be unsettled, no definite type of weather lasting more than a few hours.

Four-sevenths of all the storms of the United States come from the north plateau region of the Rocky Mountains and pass from this sub-arid region eastward over the Lakes and New England, producing but scant precipitation. The greater number of the remaining three-sevenths are first defined in the arid southwest states or territories. These nearly always can be relied on to cause bountiful precipitation as they move northeastward over the lower Mississippi Valley and thence to New England. Drouths in the great wheat and corn belts and elsewhere eastward are broken only by cyclones that form in Arizona, New Mexico, or Texas. Storms move faster in the northern part of the United States than they do in the southern portion, and their tracks migrate with the sun.

After the forecaster has spent many years in studying the courses of storms, he learns that, at times, through a gain in force that is not shown by observations taken at the bottom of the air, storms suddenly develop unexpected energy or pursue courses not anticipated in his forecast, or that the barometer rises at the center of the storm without premonition and dissipates the energy of the cyclone. Fortunately, such cases are exceptions.

Chart XII illustrates the courses of summer storms in the United States. The lines show the origin and the tracks

of the centers of the cyclones for August during a ten-year period, the anti-cyclones following about the same lines. Adding the numbers at the ends of the lines and at the braces that inclose groups of lines, it is found that 83 storms either had their origin in the states or else came to them from the West Indies or passed up through the ocean near enough to affect the Atlantic coast. The influence of the high western plateau and its mountains in the formation of storms is illustrated by the fact that 57 of these storms had their inception along the mountain system that runs through Colorado, Wyoming, and Montana, and that none came in from the Pacific Ocean. August storms move at the rate of 16 to 26 miles per hour, or about 500 miles a day. Wherever the storms originate they are seen to have a strong tendency ultimately to reach New England.

Now turn to chart XIII, which gives the storm tracks for February for a period of ten years. Against the 83 storms of August there are 98 shown for February for the same period—1884–1893. The tracks curve down farther to the south, many of them come in from the Pacific, and a large number form in Texas, but, like those of August, they finally pass over New England, which fact explains the variability of the weather of the latter region.

As regards storm conditions, the year may be divided into three parts in the Northern Hemisphere. December, January, February, and March are dominated by swiftly moving storms, swinging far to the south and carrying wide oscillations of temperature clear to the northern boundaries of the tropics, with general precipitation ; June, July, August, and September, by ill-defined storms and a sluggish movement of them, with many local rains of small area, rather than general storms, while October and November are transition periods between the summer and the winter types, and April and May between the winter and the summer conditions.

At times there is an abnormal change in the rate of drift of the highs and the lows simultaneously over the eastern and the western continents and the intervening oceans that throws weather forecasts temporarily into confusion. It is difficult to assign a reason to such sudden departures from usual conditions. It may be due to the accumulation of large bodies of air over continents or oceans from which no daily reports can be received. When momentum expends itself against gravity there may be a banking up of air in unexplored regions, and its potential may become suddenly available in such a way as to accelerate or retard the general drift of storms, or it may be due to the complex dynamics of motion of the vast gaseous sphere from which the earth receives light, heat, and various other radiations

When winter has become well established there often develops a permanent high over the great plain between the Rocky Mountains and the coast ranges, which remains inactive for weeks at a time, lows and other highs passing down from the north along its east front without materially disturbing it. Its principal function is to stop the drift of storms into the continent from the ocean immediately west of it. In midsummer the high may be replaced by a stagnant low, and hot scorching winds blow steadily for many days over the states lying east and southeast of the low, withering the wheat and corn of the central Mississippi and lower Missouri Valleys. Charts XIV and XV show the most frequent routes of storms in the Northern Hemisphere.

The influence of the area of high pressure in deflecting storms from their normal or usual course is set forth by Professor Garriott in his paper on "Tropical Storms in September." In

this paper Professor Garriott divided the tropical storms of September into three classes, namely: First, those that recurved east of the sixty-fifth meridian; second, those that recurved between the sixty-fifth and ninetieth meridians; and, third, those that passed west of the ninetieth meridian or reached the United States without a recurve. Of the first class of storms, all of which first appeared east of the fiftieth meridian or north of the twentieth parallel, Professor Garriott observes that only two appeared far enough to the south to render their advance over or near the West Indies a probability, and that in every instance the westward movement of the cyclones which recurved east of the sixty-fifth meridian was apparently prevented by anti-cyclonic areas which moved eastward over the Southern states and obstructed the westward advance and forced a recurve to the northward. He states that the recurve of storms of the second class—*i. e.*, those that recurved between the sixty-fifth and ninetieth meridians—was apparently due to the obstruction offered to a westward course by anti-cyclonic areas which had advanced or had been drawn from the continent over the west Gulf and Southwestern states. A large proportion of the third class of storms advanced westward from the eastern West Indies. On their arrival in about longitude west 80 degrees, the average longitude in which September tropical storms recurve, the pressure over the west Gulf began to decrease and rain set in, while the interior eastern districts of the United States were occupied by an extensive area of high pressure. As storms prefer to follow the path of least resistance, the centers moved toward the region of decreasing pressure and avoided the high and increasing pressure to the northward. When the pressure continued high over the eastern districts of the United States the storms were unable to recurve, and were penned in over Mexico or the Southwestern states. In such instances, Professor Garriott states, the cyclones developed great violence before disappearing. Similarly cyclones of this class that advanced northwestwardly toward the Middle or South Atlantic coast of the United States were apparently prevented from recurving by high pressure over the ocean to the northward and northeastward, and, being forced upon the coast, developed destructive energy.

From the foregoing it appears that the effect of distribution of pressure in determining a storm's path is recognized in practical forecasting.

NEW METHOD FOR DETERMINING THE DIRECTION AND VELOCITY OF STORM MOVEMENT

Local Forecaster Edward H. Bowie, in charge of the local office of the U. S. Weather Bureau at St Louis, Mo., has devised a new method of estimating the future course and rate of translation of storms, which, while not being absolute in its determinations, is a marked advance over anything heretofore accomplished in this direction. The unusually high degree of accuracy that has attended Mr Bowie's forecasts for the past several years attests the value of his system. Storms follow the lines of least resistance; but the trouble is that with the movement of vast systems of air, due to the excessive heat of the equator, combined with the rotation of the earth and the continual breaking up of the currents on the outer edges of these systems into cyclonic or anti-cyclonic vortices, the lines of least resistance are always changing, sometimes slowly and again rapidly. The usefulness of Mr Bowie's work lies in the fact that while some of his values are but roughly assigned he has been able by a study of the pressure gradients about the base of the storm, in connection with the general drift of the upper air, to obtain a resultant that approaches with close pre-

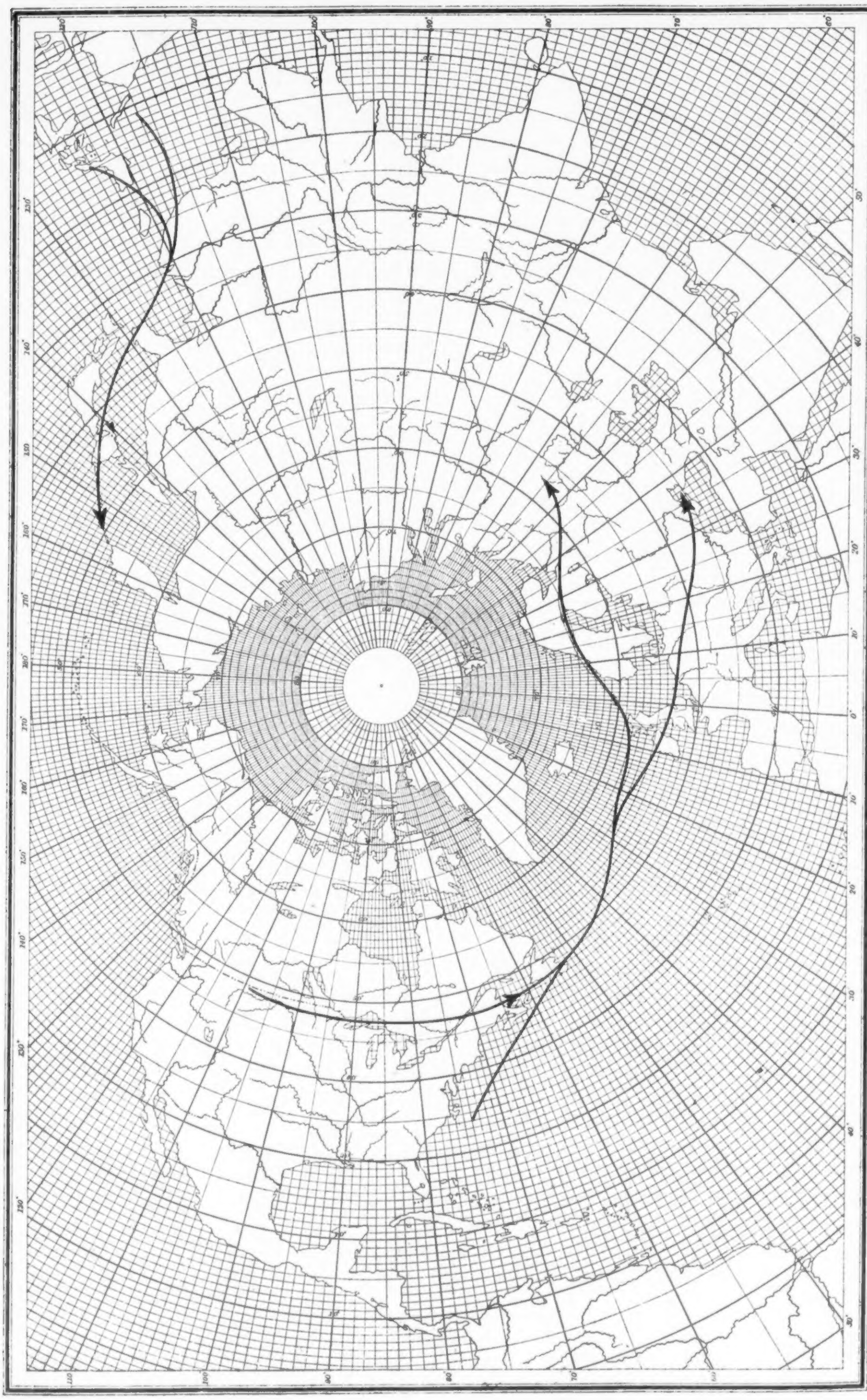


CHART XIV.—The Average Lines along which the Centers of Storms Move in July in the Northern Hemisphere

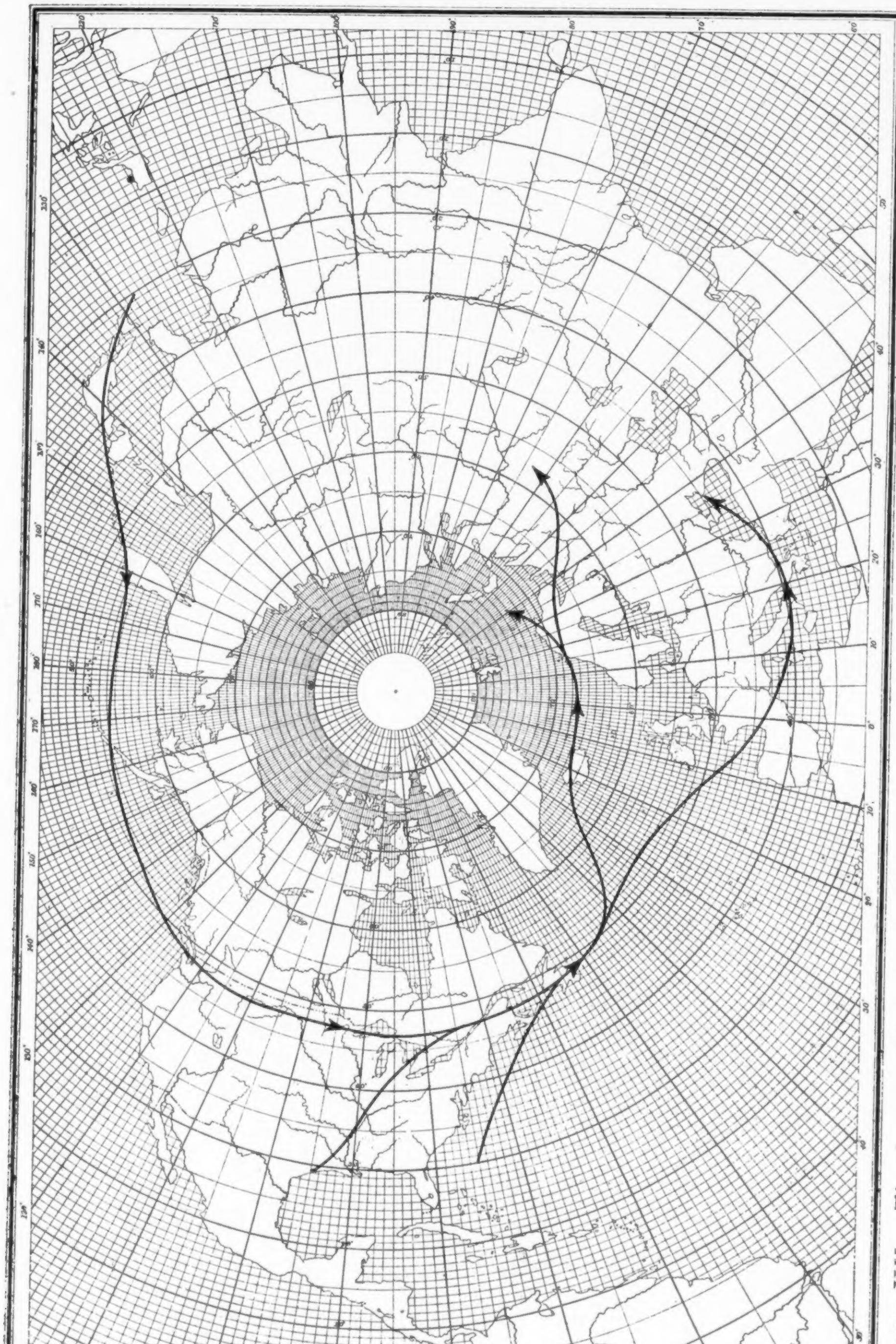


CHART XV.—The Average Lines along which the Centers of Storms Move in January in the Northern Hemisphere

cision to the line of least resistance at the moment of the taking of the observations on which the weather chart is founded. In the majority of cases his system locates the place to which the storm center will move during the coming 24 hours with considerable accuracy. It might be improved on by taking into account the *rate of change* in air pressure at all stations during the two hours preceding the observations, and constructing a hypothetical chart based upon such rate continuing for 12 or 24 hours, and then applying the system to the latter chart instead of the real weather map in the effort to determine the future course of the storm.

The description of Mr Bowie's method is told in his own words as follows:

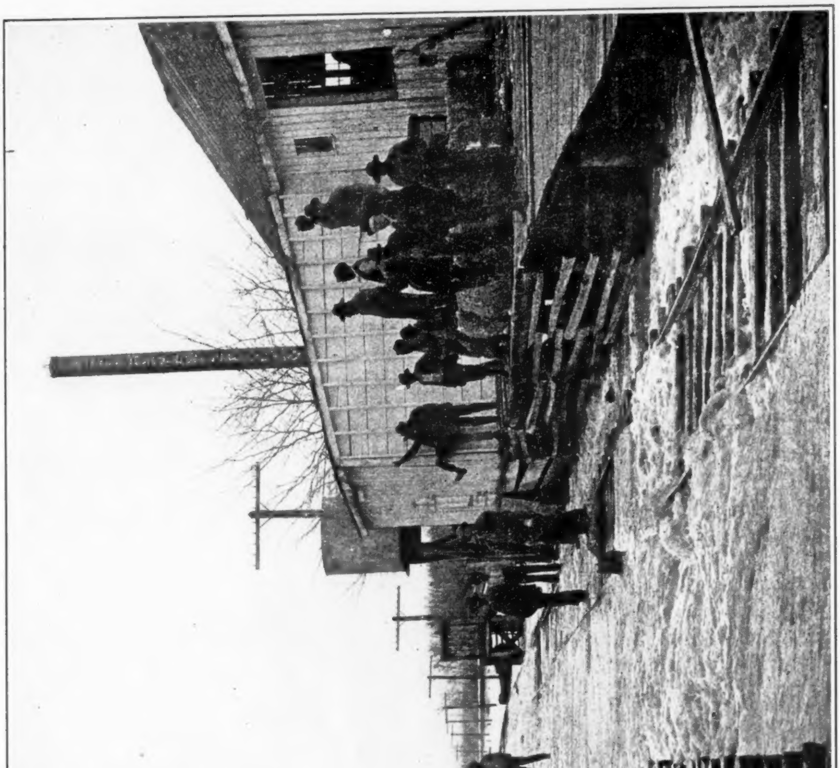
"Assuming erratic storm movement to be due to unequal pressure distribution, it is manifest that the direction and velocity of storm movement could be determined were it possible to obtain correct values that would represent the pressure exerted upon a storm from all directions and the eastward drift of air at high levels that carries the storm with it. Working on this theory, effort has been directed toward obtaining a value that would represent the 24-hour eastward drift from any given locality. To find this value it has been necessary, first, to determine the resultant of the pressure from all directions toward the storm center. To represent this pressure from all directions, lines radiating from the storm center to the north, northeast, east, southeast, etc., have been given, after considerable experimental work, a length of one centimeter for each tenth of an inch increase in barometric pressure along these lines, working with a map the scale of which is 160 miles to an inch, or that of the Washington weather map. The resultant of such lines, or forces, acting toward the storm center, which may be found by the rules governing the polygon of velocities, will show the direction toward which the unequal pressure is forcing the storm.

"If the pressure of the air from all directions toward the storm center be a factor in determining the direction and velocity of movement of a storm, it is obvious that this resultant, representing the value of and direction toward which the unequal pressure forces the storm, becomes one of the components that determine the storm's path.

"As the 24-hour movement of any given storm is the measure of the forces that determine that movement, it follows that by using this resultant of pressure toward the storm center as one of the components which cause the storm to move along its path it is possible to find the other component of motion by resolving a force representing a storm's 24-hour movement into its two components. One of these components, representing the pressure effect, being known, the other component, representing the eastward drift, may be found by the rules governing the parallelogram of forces. If there be a basis for this theory, it must necessarily be that the second component, representing the eastward drift, should have approximately the same direction and value for two or more storms in the same locality for any given month of the year, provided the appropriate value is given the pressure acting toward the storm center from all directions.

"This component has been found for a large number of storms, whose values when charted show an agreement that appears to be more than accidental or merely coincident.

"Having found the component representing the 24-hour eastward drift, which component is apparently fairly constant in value for any particular locality from year to year for a given month and the resultant of the pressure exerted on the storm center from all directions, the value of which is a variable quantity, it is patent that the direc-



A Flood Scene at Marion, Arkansas, 1903

tion and amount of movement of a storm is the resultant of these two forces. Thus, for instance, a December storm charted in Colorado, subject to a pressure that tends to force it southward 400 miles in 24 hours, is during the same period being carried eastward 450 miles by the flow of the upper currents. It is evident that the storm's actual path will lie between the two lines representing the eastward drift and the pressure that forces the storm to the south, the resulting movement being almost due southeast and a distance of approximately 600 miles.

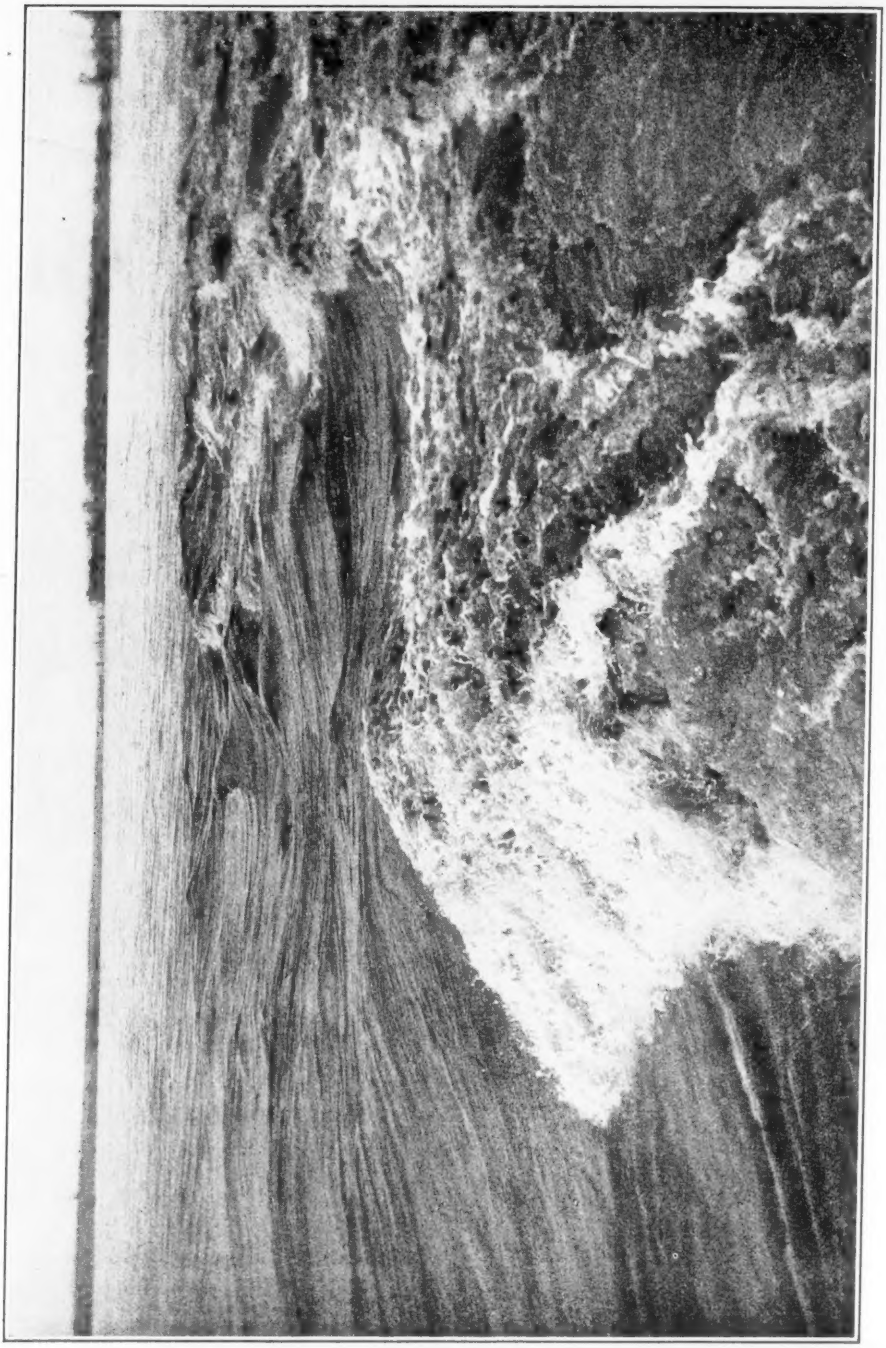
"From a study of storm movement along the lines outlined above it is apparent that the rate and direction of movement of a storm in relation to its normal movement is governed by this variable component, representing the deflective force, or the resultant of the pressure exerted on the storm from all directions; hence it follows that when this deflective force is toward the left (when facing the direction of normal progression) the storm will move to that side of the normal direction of advance, and when toward the right the converse will be true. When this deflective force is acting in conjunction with the eastward drift the storm's rate of movement will be accelerated, and when in opposition the storm's progress will be retarded. It appears that in nearly all instances the storm increases in intensity when this component, representing the pressure of the air toward the storm center, is acting to the left of the normal direction of advance, but when toward the right the storm, as a rule, will decrease in intensity.

"Naturally exceptions are to be found in applying the method outlined above, but in practically all instances the exceptions have been the result of an unforeseen increase or decrease in the pressure toward the storm center from some one of the several directions, which, in addition to offering an explanation of the exceptions, tends to prove the correctness of the principle. Of course the application of the method is limited when the storm center is near a region from which no pressure observations are available—as, for instance, the storms that move along the Canadian border. In cases where there are a number of ill-defined storm centers it is not always possible to determine which center will become the primary one and which centers will be dissipated, and therefore there is more or less doubt whether the deductions will be borne out by subsequent events. In nearly all instances involving exceptions the error in predetermining the movement of the center is apparently due to inability to determine the exact values that should be used to represent the pressure toward the storm center from the several directions.

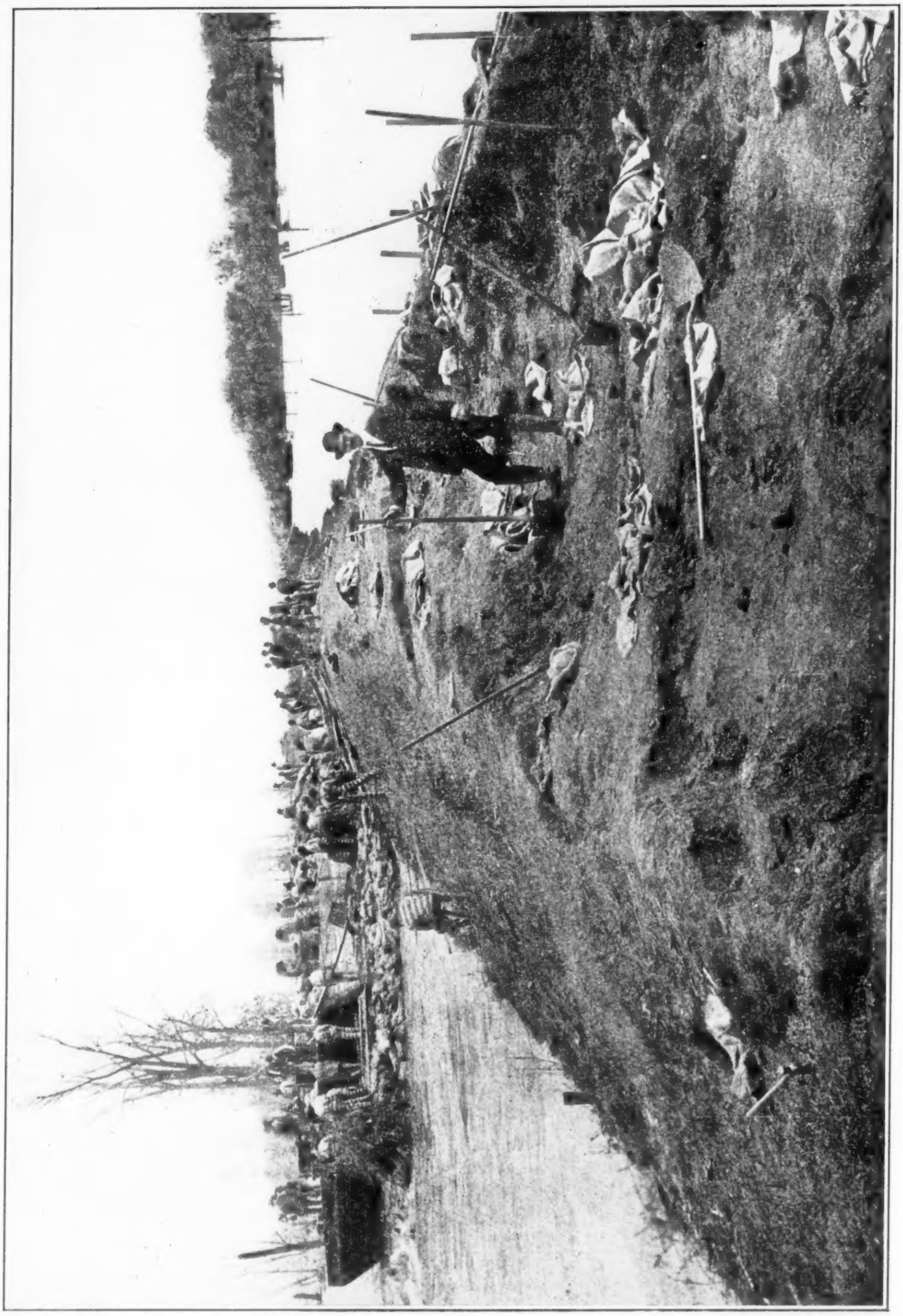
"The values determined by the methods used in the research along the lines indicated above are necessarily approximations only, and therefore tentative; but it is believed that by refined methods of computation values representing the pressure exerted on the storm center as well as the normal direction and velocity of the eastward drift can be found that will show the exact conditions, and thus lead to a higher degree of accuracy in charting the direction and movement of storms.

"The accompanying charts illustrate the method followed in developing the 'normal storm tracks' and the application of the system in practical forecasting to determine the direction and rate of movement of storm centers during 24-hour periods.

"Chart XVI shows the method followed to determine the correct value for each tenth of an inch increase in the barometric readings along lines radiating from the storm center to the north, northeast, east, etc., to represent the influence of the pressure exerted on the storm center from the several directions; it also illustrates the method followed in



The Rush of Water through the Holly Bush Crevasse, Arkansas, 1903



Strengthening the Levees in Preparation for the Coming of a Flood. Lagrange, Mississippi, 1903

developing the 'normal storm tracks' for a given locality. In this figure, drawn to to the scale of the Washington weather map, the vector X represents the direction and movement in 24 hours of the storm that was centered near Amarillo, Texas, 8 a.m., May 26, 1903. The vector X_1 is the resultant of the pressure acting from the north, northeast, east, etc., in the direction indicated, and was determined from an increase in pressure from the storm center outward at 8 a.m., May 26, as follows: To the north, 0.10 inch; northeast, 0 00; east, 0.60; southeast, 0.30; south, 0.30; southwest, 0.30; west, 0.30, and northwest, 0.20, each tenth of an inch being given a value of one centimeter. The vector Y represents the 24-hour movement of the storm that was centered over Amarillo, Texas, at 8 a.m., May 28, 1903. The vector Y_1 is the resultant of the pressure exerted on the storm center, determined, as above, from an increase in pressure from the storm center toward the several directions, as follows: To the north, 0.30 inch; northeast, 0 20; east, 0.60; southeast, 0.30; south, 0.10; southwest, 0.10; west, 0.10, and northwest, 0.40.

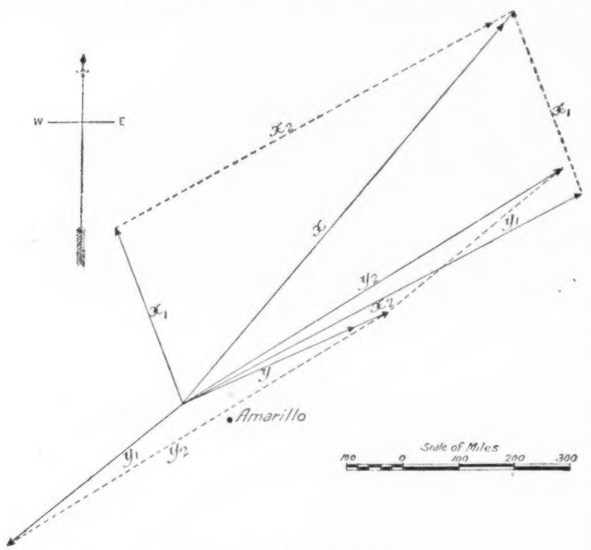
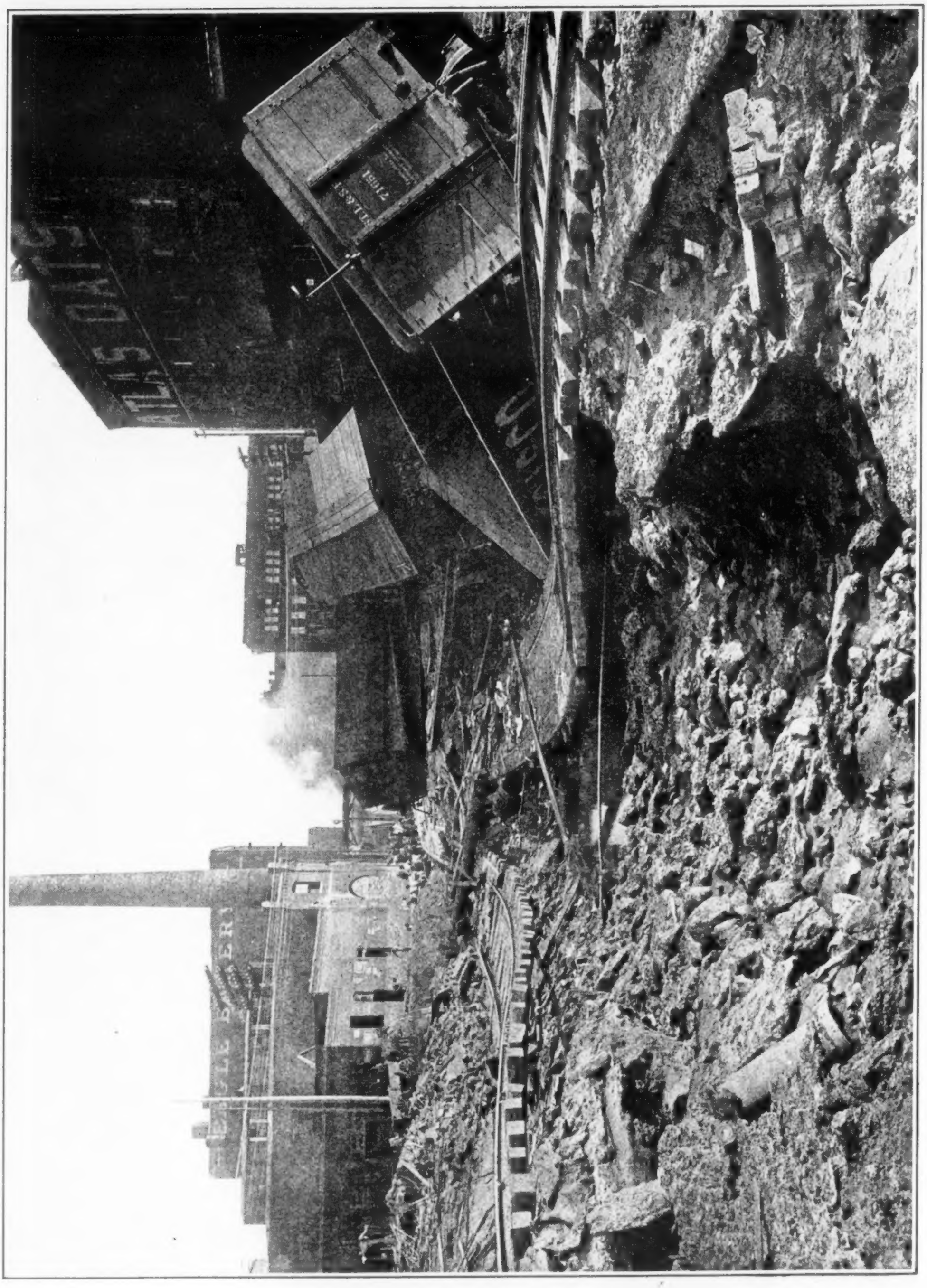
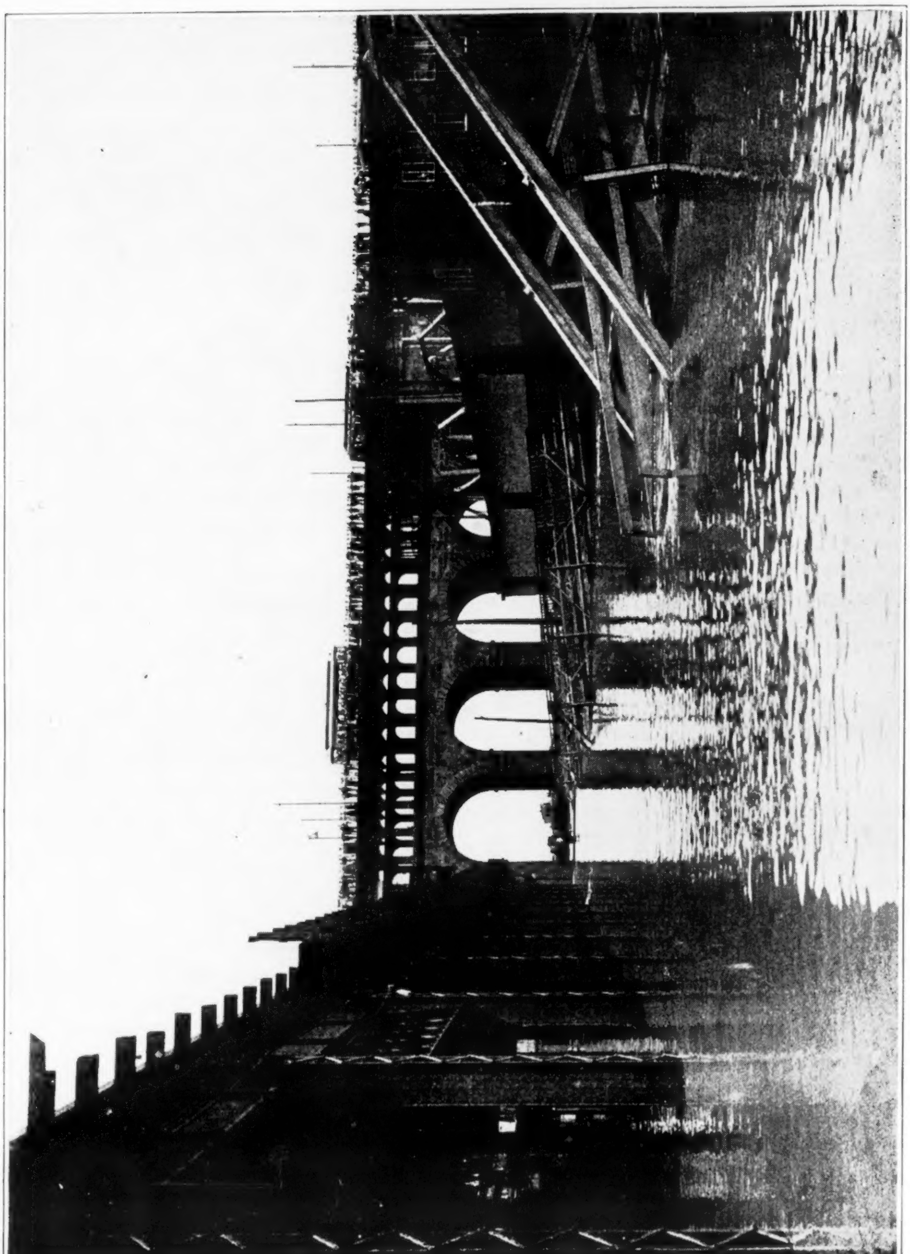


CHART XVI — Showing method followed in developing normal storm tracks and in ascertaining the correct value to represent the pressure exerted on a storm center that causes it to depart from a normal track.

"The vector X being the resultant of the forces that propelled the storm in the direction and to the point indicated in 24 hours, it is possible to eliminate the pressure influence (if it be given an appropriate value) by resolving the vector representing the track of the storm into its two components, one of which, X_1, being the resultant of the pressure exerted on the storm, the other, X_2, will represent the 24-hour value that should be given the general circulation of the atmosphere that carried the storm with it. Similarly, Y_2 represents the 24-hour value that should be given the general circulation that carried the storm of May 28 with it. It will be observed that X_2 and Y_2, representing the 24-hour values of the general circulation on the two dates, are of equal length and vary not more than 3 degrees 30 minutes in direction, from which it may be assumed that the general circulation of the atmosphere in May that carries the storms of the region of New Mexico and northwest Texas with it may be represented by a mean of a number of vectors determined as above. It is manifest, therefore, that should a storm in May in the region indicated be acted upon by a distribution of pressure whose resultant is *zero* its 24-hour direction and rate of movement will be that of the general circulation represented by a correctly determined mean of a number of vectors, such as X_2 and Y_2. Hence such means determined for the various districts of the country have been designated 'normal storm tracks,' and are shown for May in chart XVII.



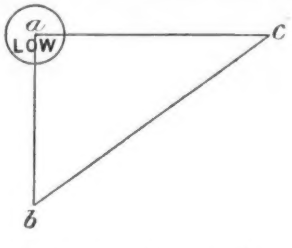
Scene in the Freight Yards at Kansas City after the Visitation of a Flood, 1903



Flood Scene in St Louis, 1903

"The value that should be given each tenth of an inch increase in pressure measured outwardly from the storm center is of vital importance to the correct working of the system, and is arrived at by constructing a number of charts similar to that presented in chart XVI. From an inspection of this figure it is apparent that if the value given each tenth of an inch increase in pressure be decreased the resultants X_1 and Y_1 will decrease in length, and the angle between the vectors X_2 and Y_2 will decrease, but the vectors themselves will become unequal—that is, X_2 will increase and Y_2 decrease in length. (The working of the system is dependent on the assumption that the general circulation, as represented by the vectors X_2 and Y_2, is fairly constant.) If the value given the pressure effect be increased, the resultants X_1 and Y_1 will likewise increase, and the vector X_2 will become shorter and Y_2 very much longer, and, at the same time, the angle made by these lines will increase, from which it follows that a value of one centimeter for each tenth of an inch increase in pressure best meets the requirements in this case."

To determine the future course of a storm in the month of May, for instance, resolve the pressure forces about the storm center into their resultant, then take for the future direction and distance of translation of the storm the resultant between this force and the force illustrated on chart XVII as the upper-air drift or normal storm track as follows:



In which the low is central near New Orleans, *a b* representing the pressure resultant, or line along which the low will be forced if acted upon by pressure gradient only, and *b c* the normal storm track, or the distance and direction of movement of the low as the result of upper-air drift alone, and *a c* the track that the storm center will follow. Hence, instead of the storm moving due south into the Gulf as the result of pressure, or northeast to southwestern Virginia, as chart XVII shows is the place to which upper-air drift will carry it, it moves due east to Jacksonville, Florida.

TORNADOES

The four conditions essential to the formation of tornadoes are usually as follows: (1) A cyclone or area of low pressure, the center of which is to the north or northwest, with a barometric pressure not necessarily much below the normal; (2) a temperature of about 70 degrees on the morning map; (3) a great humidity, and (4) that the time of year be March 15 to June 15. These conditions may and often do exist separately; one or two of them may be found coexisting; but so long as the third be absent, tornadic formation is not likely to occur.

The number of these storms is not increasing; the breaking of the virgin soil, the planting or the cutting away of forests, the drainage of land surfaces by tiles, the stringing of thousands of miles of wire, or the laying of iron or steel rails have not materially altered the climatic conditions or contributed to the frequency or intensity of tornadoes. As well might one by the casting of a pebble expect to dam the waters of the Mississippi as attempt the modification or restriction by the feeble efforts of man of those tremendous forces of nature that surround our earth and control our storms and climate. To be sure, as towns become more numerous and population becomes more dense, greater destruction will ensue from the same number of storms.

It is not possible with our present knowledge of the mechanism of storms to forewarn the exact cities and towns that will be visited by tornadoes without alarming some towns that will wholly escape injury; but we know that tornadoes are almost entirely confined to the southeastern quadrant of the cyclone, and that when the thermal, hygrometric, and other conditions are favorable, the spot 300 to 500 miles southeast from the cyclonic center is in the greatest danger. This fact is well illustrated on chart XVIII, showing the cyclonic system that existed at 8 p. m. on March 27, 1890, the day of the famous Louisville tornado. Two red lines, drawn at right angles to each other, divide the area of the storm into four quarters. Twelve tornadoes, represented by short red lines, mostly in the southeast quarter of the general cyclone, occurred during the afternoon or evening of the day. As most of these occurred several hours before 8 p. m., the time of the taking of the extensive system of observations on which the chart is based, when the center of the cyclone was 100 or 200 miles farther west, it is apparent that they all operated somewhere within the southeast quarter of the general storm, although exceptions to this rule occasionally occur.

It is desirable to make clear the difference between the cyclone and the tornado. The majority of the press and many persons who should know better use these terms as synonymous. The cyclone shown on chart XVIII, which is fairly typical of all cyclones, is a horizontally revolving disk of air, covering the whole United States from the Atlantic Ocean westward to and including the Mississippi Valley, with the air currents from all points flowing spirally inward toward the center, while the tornado is a revolving mass of air of only about 1,000 yards in diameter, and is simply an incident of the cyclone, nearly always occurring in its southeast quadrant. The cyclone may cause moderate or high winds through a vast expanse of territory, while the tornado, with a vertical motion almost unmeasurable, always leaves a trail of death and destruction in an area infinitesimal in comparison with the area covered by the cyclone.

The tornado is the most violent of all storms, and is more frequent in the central valleys of the United States than elsewhere. It has characteristics which distinguish it from the thunder-storm, *viz.*, a pendent, funnel-shaped cloud and a violent, rotary motion in a direction contrary to the movements of the hands of a watch, together with a violent updraft at the center.

Right here it is well to inquire if a satisfactory reason can be given for the occurrence of these violent agitations of the atmosphere mainly during the spring and early summer, and usually only in the southeast quarter of the cyclone. In answer it may be said that an hypothesis can be formulated that fairly well satisfies the requirements of the case. First, one must recall the fact that the atmosphere, even at the surface of the earth, is not dense enough to absorb but a small part of the solar heat waves. They therefore reach the earth and warm its surface, but the absorbed heat does not penetrate to any great depth, because the land is a poor conductor, but a good absorber and a good radiator. The land therefore retains its absorbed heat near the surface and quickly and freely radiates that which it has absorbed. The atmosphere, which is a poor conductor, is thus rapidly warmed at the bottom, but the heat is slowly conducted upward, and in the spring of the year the gaining intensity of the solar rays and the increasing hours of sunshine warm a thin stratum of air next the earth to an abnormal degree of heat in comparison with the stratum next above, which

still retains the cold of winter. This abnormality is accentuated in the southeast quadrant of the cyclone, wherein southerly winds still further add to the heat of the lower stratum and increase the humidity. An unstable condition then ensues, in which heavier air is superposed on lighter and much warmer air. This unstable equilibrium is more often relieved by the breaking through, here and there, of masses of the heavier air and its horizontal rolling along the surface of the earth, with the warm and cold masses driven together by electric explosions; these are thunder-storms. But at times dry and extremely cold air are brought together with humid and very warm air, with the result that a narrow vertical whirl is set up which develops great vortical energy; this is the tornado. The tornado also may be caused, and many times is, by the cyclone whirling together on the same level the cold currents from the northwest and the warm ones from the southeast, especially at an elevation of a few thousand feet, in the interior layers of the cyclone. The vortex then burrows downward to the surface of the earth, or dances along with the tail of the funnel whipping from side to side, and touching only the high places or nothing at all.

Tornadoes mostly occur between 2 and 5 in the afternoon, and generally move from the southwest to the northeast; their tracks may vary in width from a few hundred feet to one mile; their velocity of translation is usually about that of an express train; their speed of gyration can be measured only approximately, but as it is sufficient often to drive straws a half inch into the bodies of trees it must equal or exceed the velocity of a rifle bullet. Professor Biglow says: "The vortex of a tornado obeys the laws of the movements of fluids in gyratory circulation. If a mass of air 6,000 feet in diameter is rotating at a half-mile level and it runs into a vortex so that the tube is 100 feet in diameter at the top, and supposing the outer edge of the upper vortex makes 7 miles an hour, then at the rim of the bottom of the vortex we should have a velocity of 200 miles an hour. This causes an enormous centrifugal force in the lower tube, a high vacuum, and low temperature. The vacuum tube causes the explosive and disastrous effects upon objects in its path." The cold of expansion condenses the vapor that makes the tube visible, and the sudden condensation causes electric discharges of great violence. A roaring like the sound of a thousand express trains accompanies the tornado, whose track is usually 5 or 10 miles in length, and whose rate of movement is about 30 miles per hour.

The writer visited St Louis the day after the tornado of May 27, 1896. He was especially impressed with the fact that many of the buildings seemed to be burst outward at their upper stories, indicating that at the time of their destruction they were near the center of the rotating mass of air, where centrifugal force had reduced the air pressure on the outside to such an extent that the expansion of the air in the upper stories of the houses whose windows and doors were closed had produced an explosion of the building. In one case all the four walls of the upper story of a house were thrown outward, leaving the lower story intact and the roof resting in proper position one story lower than in the original building. Again, great structures seemed to have been crushed over or taken up bodily and scattered in all directions.

The fact that this tornado traveled with destructive force through several miles of brick buildings and yet left the city with greater force than it possessed on entering it illustrates the futility of planting forests to the southwest of cities for purposes of protection, as some have advocated. The strongest

trees would offer but little more resistance to the tornado than would so many blades of grass, and the drawing off of the electricity of the clouds by the projecting points of the trees would have no effect, as it never has been shown that electricity has anything to do in originating tornadoes; it is rather a result than a cause. The planting of trees is a useful occupation, even if they have no effect on tornadoes; but what shall one say of the municipality that hires a cannoneer to guard the southwest approaches to its city and to destroy with shot all tornado clouds, as a small western city once did. Still its action was no more ridiculous than is that of certain provinces in Europe that annually expend large sums of private and public money in the shooting of hail clouds, or of otherwise intelligent people who aid and abet the most ignorant of charlatans in their pretensions of making rain or of forecasting the weather months in advance.

There is a wide variation in the number of tornadoes that occur during the years. Chart No. XIX shows the location and the direction of movement of all the tornadoes of a year of small number, and chart XX shows the result of a year of great frequency.

FLOODS

With our many thousands of miles of navigable rivers flowing through one of the most extensive and fruitful regions of the world, daily forecasts of the height of water in the various sections of each river are of enormous benefit to navigation, and the warnings issued when the precipitation is so heavy as to indicate the gathering, during the near future, of flood volumes in the main streams are often worth many millions to navigators and to those having movable property on low grounds contiguous to the streams.

The feasibility of making accurate forecasts as to the height of water several days in advance at any station of the system is no longer questioned, and at stations on the lower reaches of rivers one to three weeks' forecasts are feasible. The forecaster at each river center considers the rainfall, the temperature, the melting of snow, if there be any, the area and slope of the watershed, and the permeability of the soil. From a study of floods in former years he knows the time necessary for the flow of the water from the tributaries to the main stream and the time required for the passage of the flood crests from one city to another. The forecasts are, of course, empirically made, but still they are sufficiently accurate to possess great value to the people of the river districts.

Some idea of the vast destruction of property due to floods may be gathered from the statement that the floods of 1881 and 1882 caused a loss of not less than $15,000,000 to the property interests of the Ohio and Mississippi Valleys. There was also a loss of 138 lives. In 1884 the region of the Ohio alone suffered a loss of over $10,000,000 in property. In 1897 the loss along the several great rivers was more than the sum of the two large figures just written, and in 1903 the destruction of property might fairly be estimated at $40,000,000 in value.

From data that now covers many years at a large number of stations the following general relations have been deduced: The time it takes high water to pass from Pittsburg to Wheeling is one day; from Pittsburg to Parkersburg, two days; from Parkersburg to Cincinnati, three days; from Cincinnati to Cairo, six days; from Cairo to Vickburg, seven days, and from Vicksburg to New Orleans, four days. The time, therefore, from Pittsburg to the Gulf is 23 days. Similar general relations concerning the movements of other rivers have been determined. Since the time is so great—the movement of high water being a little slower than the current—

it follows that many interfering conditions may arise, tending to retard or accelerate the passage of the crest of the flood wave. No absolute rule is, therefore, possible; but the forecasting of the exact flood stage many days, or even weeks, in advance at important river stations is of such frequent occurrence as to indicate that, although the forecasts are empirically made, they have a substantial commercial value.

Each forecaster in charge of a river center has a definite section of the river system to watch and for which he must forecast. He receives the necessary telegraphic reports of the daily rainfall that has occurred over the tributaries to his river district, reports of the gauge readings nearer the source of the main river than his own station, and gauge readings from many of the tributary streams. He is familiar with the area of the catchment basin from which his rainfall reports are received, the contour and configuration of the surface, and the permeability of the soil. A slowly falling rain of considerable amount on a nearly level and permeable soil may cause little rise, while a rapidly falling rain of the same amount on an impermeable and greatly inclined surface will gather quickly in the channels of the tributaries and soon become a rushing torrent in the main stream. It is thus seen that many modifying conditions must be taken into consideration. The forecaster studies the history of previous floods under various temperatures and absorptive conditions of soil. He knows that the rainfall may be augmented by the melting of snow, if any there be on the ground, and that the temperature is an important factor in the flood; that on a frozen soil, under moderate heat, the entire precipitation, plus meltage, may flow away without appreciable absorption or evaporation and create higher water in the rivers than would be the case if the soil were open, and that an unfrozen but saturated soil presents to the flowing water practically the same surface, so far as the latter affects the flood, as a frozen soil. Of the precipitation that is absorbed a part is evaporated, a part taken up by vegetation in making its growth, and the remainder sinks to the impervious rock, which lies at no great depth below the surface. It slowly follows the slope of the rock, and gives rise to the springs that supply the steady flow of the streams and rivers. This portion of downpour, while unimportant in the causing of floods, needs to be considered by the river forecaster, for an abundance of well-absorbed rains during the spring and early summer means the maintenance of fair stages in navigable rivers during the usual low-water season, and forecasts of low-water stages are nearly as important to commerce as the prediction of flood heights. In brief, floods have their origin in the surface discharge, while the low-water flow of streams is mainly due to the underground waters.

The *zero* of a river gauge is placed at the level of the lowest water known, and if at any subsequent time a stage still lower is recorded it is read as a minus quantity. The *danger line* varies with the locality. On the Ohio river, on account of its narrow channel and its precipitous banks, the water must show vertical rises varying from 30 to 50 feet before the danger line is reached. At Cincinnati the danger line is 45 feet above the zero of the scale, and a height of 71 feet has been recorded. On the upper Mississippi the danger lines average about 15 feet above zero, but from St Louis to Vicksburg they average about 35 feet, while at New Orleans the danger limit is but 13 feet above zero. An impermeable ground, such as that over granite bed rock, is marked by many rivulets and streams in comparison with the number that are found in a permeable soil of equal rainfall. When

at great intervals a stream does appear in permeable ground the flow of water may diminish as the stream progresses, the water being absorbed by the soil or sinking through it to the bed rock. Much of the water absorbed never reaches the rivers. In the Ohio Valley the amount of water drained away by the rivers is about one-fourth of the rainfall, which is the same as in Europe; in the Missouri Valley the amount is only one-eighth. These conditions have an important bearing when considering what river stages will be effected by a given rainfall and what will be the rate of rise. In an impermeable region the rivers rise rapidly and as quickly subside; in a permeable region the rise and the fall are slower in action and the amplitude of the movement less.

In small rivers the slope may fall away at the rate of four to seven feet the mile, while in large rivers, like the Mississippi, the slope is only about one-fourth of a foot. The velocity of a river does not depend alone upon the slope, but also upon the mean hydraulic depth, the square root of the two measures determining it closely.

The *regimen* of a river is the history of its movements and their causes. It may be modified by a change in forest areas or in the area under cultivation. Cultivated ground allows of a much greater absorption than wild soil, and therefore holds in storage and conserves the supply for springs and streams after flood seasons have passed. It is therefore a question if civilization has not thereby considerably reduced the intensity of floods, notwithstanding the cutting away of forests, the area cleared of forests being small in comparison with the total area changed from a wild to a cultivated state; but before a hasty conclusion is reached one should not forget to consider that forest coverings reduce to a minimum the amount of silt carried to streams, especially from steeply tilted surfaces. They hold the soil and prevent its washing away to the rivers, where it is deposited in such a way as to build up the river beds and possibly cause greater overflows than with the former larger volume of water and less silt. Many have thought that the leveeing up of the Mississippi River will cause a building up of the bottom of the river by the confining between banks of large quantities of silt-laden water that formerly deposited most of its sediment on the adjacent flats before moving down the stream; but here again account is not taken of the fact that the leveeing up of the river increases its depth, and therefore its velocity, and the carrying capacity of a stream increases as the cube of its velocity. It is probable that the bed of the river has not risen since a considerable portion was confined by levees. Many gauges that were established more than thirty years ago occasionally show minus readings.

The various flood scenes illustrated in this paper tell each its own story.

GEOGRAPHIC NOTES

WHAT IS THE POPULATION OF CHINA?

WHEN I first studied geography the population of China was estimated at 230 millions; then came an advance to 360 millions; now we hear of over 400 millions, and if the latest figures are correct there is reason for talking of the "Yellow Peril."

Upon what have these estimates been based? Has anything like a census ever been taken of the Chinese people? Probably not, though the Peking government, no doubt, receives reports concerning the number of people in the different provinces. The published information must have been derived mainly from travelers, missionaries, diplomats, and naval officers.

From my own observations during the three years I was on the Asiatic Station, I would say that there are less than 200 millions of people in China, and perhaps some of the contributors or readers of the NATIONAL GEOGRAPHIC MAGAZINE, who have had better opportunities to judge, will show why or to what extent I am wrong.

I spent several months in each of the principal seaports from Tientsin in the north to Canton in the south and five or six months in the Valley of the Yangtze, going as far inland as Ichang, a town nearly 1,000 miles from the sea, and beyond the reputed populous districts. I noticed that the country people instead of living on farms were concentrated in villages, and that these were generally small and often widely separated.

The cities were limited in area and contained no lofty buildings, one and two storied houses being the rule. Canton is the wealthiest, and, with the possible exception of Peking, is the most populous city. I was with a party that made the circuit of the walls, several members walking the entire way in a little over two hours, which proves that the enclosed space could not have exceeded six square miles. In the northern part we saw gardens and unoccupied ground. Compare this with Manhattan Island, with its 22 square miles and lofty tenement houses.

The streets of a Chinese city are very narrow, and the people live in them and on the ground floor of the wide open shops and houses, therefore the visitor seems to be always working his way through a dense crowd.

I believe that tigers are encountered in all portions of China. It is certain that they are killed north of Peking, as the skins are sold there, and at Amoy the missionaries, who had been inland, told me of the terror they inspired. As there is little of the dense undergrowth of India it is a comparatively open country through which the tiger prowls, and his presence certainly does not suggest a land densely populated.

C. E. CLARK,
Rear Admiral, U. S. Navy.

The article on "Forecasting the Weather and Storms," by Dr Willis L. Moore, Chief of the United States Weather Bureau, published in this number, is an advance chapter from "The New Meteorology," a text-book on weather science which is in course of preparation by Dr Moore and which will be published in a few months by a well-known firm. The chapter is published here in advance of the appearance of the book through the courtesy of Dr Moore. The members of the Society will undoubtedly enjoy the interesting and lucid explanation of storms and weather given by Dr Moore, and will also appreciate the good-will of an author who permits the publication of a chapter in advance of the completed volume.

The map showing the present seat of war in eastern Asia which appears as a supplement to this number of the NATIONAL GEOGRAPHIC MAGAZINE was prepared by the Military Information Division of the War Department and is republished by the National Geographic Society through the courtesy of Major Beach, chief of the division. It is believed that the map will prove particularly useful to those who are following military developments in Manchuria.

GEOGRAPHIC LITERATURE

Excursions and Lessons in Home Geography. By Charles A. McMurry, Ph. D. Pp. 152. 5 x 7½ inches. New York: MacMillan Co.

A much-needed book, containing many fine illustrations. The student can find out from its pages anything from the way his own particular part of the country was formed to the most approved method of milking cows and maintaining a sanitary dairy. The book is written in such simple language and is so well expressed that any one can understand and enjoy it.

The Philippine Islands, 1493–1898, vol. XXI. Edited by Emma Helen Blair and James Alexander Robertson. Pp. 317. 9⅝ x 6⅛ inches. Cleveland: The Arthur H. Clark Co. 1905.

In this 21st volume the publishers have got down to the year 1624 in their monumental undertaking. This one deals entirely with religious matters for that year, being composed of sources bearing on ecclesiastical squabbles, the founding of a Japanese seminary, and the labors of the early Recollect Missions. The last forms more than half of the book, and, like Jesuit writings, contains very valuable descriptions of the country, the people, and their customs. Typographically the book is almost perfect for use, the print being large, the paper heavy, and the binding excellent. It seems a great pity that this enterprising firm should suffer a loss in their effort to advance the cause of knowledge. C. M.

Along the Nile with General Grant. By Elbert E. Farman. Pp. xviii + 339. New York: The Grafton Press. 1904. $2.50 *net*.

The voyage of General Grant up the Nile to the First Cataract, in 1877, serves in this volume as a reason for its publication. The chapters on Luxor, Abydos, Thebes, the Temples of Karnak, and the Islands of Philae and Elephantine are evidences of Judge Farman's careful observations of the remarkable antiquity of Egypt. The volume is unusually well illustrated, and will be of special interest to those who have made, or contemplate making, the tour of the Nile. A. W. G.

Dodge's Advanced Geography. By Richard Elwood Dodge. Pp. 333 + xix. 9 x 7⅞ inches. Chicago: Rand, McNally & Co. 1904.

The distinguishing conception of this work is the emphasis laid upon the "causal notion" in geography—that is, that our civilization is the result of natural conditions. First come geographic principles, then their application in the second part, with a rapid view of the different continents and leading countries of the world. The orderly growth of industrial life from natural conditions is the central theme in all cases. Each important region is represented by three maps, relief, political, and commercial. There are many beautiful illustrations and helpful suggestions.

The writer of the text has likely never gone over this ground thoroughly as a teacher, else some defects would be absent. It seems a waste of space to tell us that little is known about polar winds (50). There is much haziness about monsoons and summer and winter winds (48, 49, 50). There is a troublesome mixture of the terms "miles" and "degrees" (89). It is confusing to speak of "northwest trade-winds" (319). Yokohama does not have an excellent harbor. To speak of Georgia growing sugar "extensively" (144) and then in the diagram (149) to show how insignificant her total is will puzzle most young minds. The work of the cartography "expert" is decidedly the most unsatisfactory part of the book. He has sugar-cane over nearly all of South Carolina (148). He has a big cotton area in the middle of the south Pacific (330). In other places he fairly riots in details, crowding his maps to

such an extent that they are scarcely more than "labored ingenuities." Many of them are utterly beyond the capacity of children of the age of those who are expected to study this book. So far as the publishers' part goes, the maps are of the best workmanship, except that the contrast of colors in the physical ones is not so marked as it should be.

But in spite of these weaknesses there is hardly a volume the equal of this for developing the thinking powers of the pupils, and hence is the best this reviewer knows of. C. M.

The United States of America. By Edwin E. Sparks. 2 volumes, maps. Pp. xi + 425 ; vii + 385. Illustrated. New York : G. R. Putnam's Sons. 1904.

This is a most welcome and valuable addition to The Story of Nations' series. It commences with the treaties of peace in 1783 and traces the evolutionary stages through which the United States passed, from a confederacy of republics to its present status as a powerful nation, clothed with all powers needful for its progress and preservation.

Perhaps the most interesting chapters are those outlining the fundamental bases on which centralization has been effected. Therein Prof. Sparks clearly indicates the most potent lines of action and their specific effects. The Jeffersonian ordinance of 1784 with unqualified suffrage, the erection of the back lands into equal independent states, the home-making public-land system, the light-house and post-route policies, the assumption of the states' debts, the entrustment of the militia to executive control, the appropriations for scientific purposes, the adoption of excise and tariff measures, and the construction of the general welfare clause of the Constitution are given due weight and consideration.

As to the later phases of our national history, the chapter on profit-sharing and paternalism, on abolitionism and colonization, and the passing of strict constitutional construction throw instructive side lights on the march of events.

National industrial development is too currant and political a topic for purely historical treatment, and from the nature of the case cannot be universally accepted.

Altogether, the literary style, subject-matter, and method of treatment are excellent. There is not a dull chapter in either volume. A. W. G.

Grundriss der Handelsgeographie. von Dr Max Eckert (Privatdozenten der Erdkunde an der Universität Kiel). Pp. xv + 517. 9 x 6 inches. Leipzig : G. J. Goschen'sche Verlagshandlung. 1905.

This is a very comprehensive summary of facts rigidly based on the great causal notions of geographic development. Following a simple and uniform plan, our author treats the continents and then the countries of the world, first giving a brief view of the land and the people of each, then the natural resources, then the industries and occupations, and, finally, communication and trade. The three great divisions of the material world, plants, animals, and minerals, are in each case described, with the next section pointing out the industries that have sprung up in that country, but he leaves the student to supply the links of connection ; and that brings up one serious defect of the work. It is a frightfully dry compilation of names and figures, unrelieved by any graces of expression or interesting incidents. It is difficult to see what place it would fill in education, as it is too heavy for American students, and many of the statements are annually superseded by almanacs or hand books. It is not sufficiently scientific to be accepted as an authority in itself, since the sources of information are not often given. For general style and interest it is much inferior to the International Geography. C. M.

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